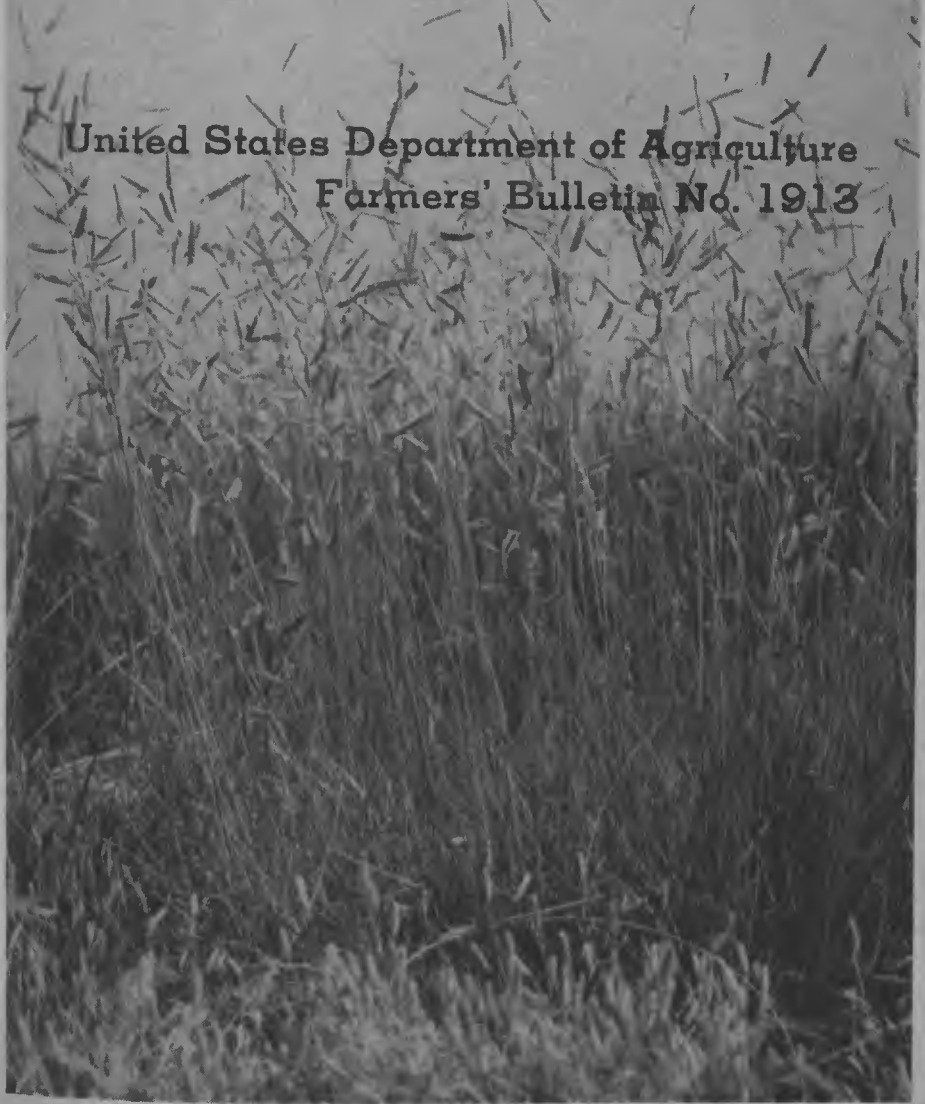
Regrassing for Soil Protection in the Southwest



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THE ENTRY of the United States into the war emphasizes the timely value of this bulletin for ranchers and farmers who now face the vital necessity of increasing meat production at a time when their principal problem is to make the most effective use of the limited capacity of their lands to grow forage.

Because of need for meats, it is important that every acre be made to produce its greatest yield of nutritious grasses, not only this year, but next year, and so on for the duration of the war.

This bulletin is designed to help the stockmen and farmers, of the Southwest particularly, in reestablishing depleted ranges where unfavorable climatic conditions and heavy demands on the range have served to make improvement of the range by natural means a slow and difficult process. It discusses the latest methods of artificial revegetation that have proved most effective in regrassing the ranges. It also discusses the more promising grasses and indicates the areas to which they are adapted. It explains the latest methods for harvesting seed and establishing grass on various sites under a wide range of conditions as to elevation, temperature, rainfall, and soils.

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REGRASSING FOR SOIL PROTECTION IN THE SOUTHWEST

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Contents

INTRODUCTION

THE history of semiarid pastoral countries of the Old World affords ample proof that range resources are not limitless. In our own country, forage production has been decreasing at an alarming rate during the past few decades. The decrease has resulted from the cumulative effects of drought and misuse of land and forage with the resultant loss of topsoil. If drastic and immediate action is not taken to stop further deterioration of soil and forage resources, it seems inevitable that depletion will continue until the so-called Great American Desert in fact becomes a wasteland (fig. 1).

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[2] The autbors gratefully acknowledge tbe helpful assistance of J. L. Lantow, Range Division, L. N. Goodding, J. A. Downs, and H. R. Benbam, Nursery Division, Southwest Region, Soil Conservation Service, and of the many other Federal and State officials whose concerted efforts are being directed toward the solution of southwestern range revegetation problems.

NM-9209

FIGURE 1.—A once verdant and productive range changed to a desert of drifting sand by the destruction of the grass cover. Laguna, N. Mex.

Range lands have reached a point where careful management and restorative measures are necessary to prevent still further depletion. Livestock men of the Southwest, realizing that forage production is decreasing, are seeking information about adaptable forage plants, sources of seed for range-reseeding purposes, methods of growing and gathering seed, and methods of successfully reestablishing an erosion-resistant cover of high forage value.

The information reported in this bulletin has been obtained from observations of extensive range plantings made during the past 6 years by the Soil Conservation Service in collaboration with individual ranchers and farmers, and of Soil Conservation Service nursery tests of promising grasses to determine their adaptability and methods of establishment. These experimental tests at the nurseries are carried on in collaboration with the Research Division and other technical divisions of the Service interested in revegetation and in cooperation with the Bureau of Plant Industry and the State agricultural experiment stations.

Discussion is limited for the most part to range areas having a relatively low annual precipitation. Methods of artificial revegetation in areas having moderate to heavy annual precipitation, wet meadows, and irrigated pastures and descriptions of plants suitable for such areas have been presented previously in other Federal and State publications.

The area considered includes Arizona, Utah, and those portions of adjacent States having comparable conditions. It also includes the parts of Colorado and New Mexico that do not belong to the Great Plains.

NATURAL REVEGETATION

RECOVERY DEPENDENT UPON THE DEGREE OF DEPLETION

A program for revegetating depleted range lands should first take into consideration the possibilities of rehabilitation and restoration through natural means before undertaking the more costly artificial revegetation. Reestablishment of a vegetative cover can be accomplished on many depleted ranges by conservative grazing and proper handling of livestock if a sufficient number of desirable, well-distributed range plants still remain on the land (fig. 2). These plants may be small and weak and exist only in a thin stand. Their restoration will depend upon light grazing for a period of time sufficient to restore their vigor, produce seed, and allow seedlings and new offshoots to become established (fig. 3).

Restoration by reestablishing native vegetative cover may take as long as or longer than is necessary to obtain a stand from an entirely new seeding. Water-detaining and water-spreading structures hasten recovery in many places, especially on badly depleted ranges where soil moisture is low because of heavy runoff due to the imperviousness of the soil or the violence of the rainfall (fig. 4).

Overused ranges on which the density of the forage stand is still fairly high are commonly found in the Southwest. Invariably, however, the grass plants on such areas are weak and small, and the root

NM–9282

FIGURE 2.—This blue grama range near Las Vegas, N. Mex., is an example of the response of range land under proper management. Under such management there is maximum penetration of water; grass plants are vigorous and produce a maximum volume of forage; and soil losses are at a minimum. Note the absence of weeds and undesirable plants since the grass occupies the surface to such an extent that other plants cannot invade the area.

systems are too short to extend to the zones of moisture and nutrients that are within easy reach of the longer roots of vigorous plants. Such ranges make very little forage growth and produce little or no viable seed. In many places it takes years of nonuse or light use to restore them. Studies made by the Soil Conservation Service on ranges completely protected from use by livestock indicate that the rate of recovery may be extremely slow. Although in some instances exclusion of livestock resulted in improvement within 3 years, in others

NM—7252CL

FIGURE 3.—Range restored by proper management. Left of the fence, a depleted range invaded by unpalatable shrubs, but showing grass remnants. No grazing was done during the season. Right of the fence, the grass has been restored by 6 years of proper use and the shrubs killed. Near Las Cruces, N. Mex.

there was little apparent change in 6 years. In some cases it may be a decade or more before a highly vigorous and productive stand can be reestablished. The time necessary for restoration depends mainly on the degree of depletion, the intensity of use by livestock, and climatic conditions.

RELATION OF CLIMATE AND USE TO FORAGE PRODUCTION

On southwestern ranges, climatic fluctuations between years of maximum and minimum precipitation; are extreme. For instance, Carrizozo, N. Mex., in 1917 had a total precipitation of 3.25 inches but had 34.1 inches in 1931; Yuma, Ariz., had a total of 0.47 inch in 1928, as contrasted with a total of 11.41 inches in 1905.

The volume of forage produced is determined to a great extent by climate, particularly the amount and seasonal distribution of the precipitation. Several years of below-average precipitation may follow each other in succession, causing a prolonged period of drought. During such periods, there is little production of forage, and the stand

A, NM–11157; B, NM–11159; C, ———

FIGURE 4.—Various types of water-spreading and water-detention structures are used to hasten recovery of blue grama ranges where runoff is heavy. *A*, Contour furrows, and *B*, brush percolators, near Cuba, N. Mex. *C*, Loose-rock percolators, near Hillsboro, N. Mex.

of desirable erosion-resistant and palatable species is reduced. Properly used ranges will regain their stands and productivity rather rapidly with a return of favorable climatic conditions, although in some instances they may require as much as 3 to 5 years. If the ranges have been overused, permanent injury may result.

Ranges that have been long overgrazed do not respond readily to increased rainfall. Even under the most favorable conditions the maximum forage production of such ranges may be less than the minimum production of a properly used range under the most adverse drought conditions.

It is still commonly believed in many localities that decreased forage production has been due entirely to drought, whereas actually it has resulted primarily from overgrazing. For example, weather records for at least two locations in the Southwest (Carrizozo, N. Mex., and Willcox, Ariz.) indicate that there was a higher average precipitation during the past 10-year period than in any recent decade. Nevertheless, forage production in these localities has decreased, as in the rest of the Southwest generally. With total precipitation for the period appreciably above normal, it is reasonable to assume that at the locations mentioned the decrease in forage production was due primarily to overgrazing.

Density of black grama in some areas of New Mexico [3] decreased as much as 89 percent in a single year of drought. During the drought year 1934 in western Kansas about 75 percent of short-grass plants were killed on overgrazed pastures, but only about 65 percent on pastures moderately grazed.[4] During the same year, in Arizona, grass density declined 70 percent on properly grazed pastures, but under certain soil conditions the grass on heavily grazed ranges [5] was killed completely. Continuous close removal of the food-manufacturing leaves of the grass plant so starves it and uses up so much of its reserve food that ultimate adjustments can be made only by reduction and shortening of the root system, which causes a decline both in size and vigor of the plant. Grama plants weakened to the extent shown in figure 5, *B* and *C*, have little chance for survival in severe droughts. The ranges on which the grass stand disappeared during the dry year 1934 were populated by small grass plants without vigor and with weak root systems.

In Idaho, during the period 1924 to 1932, it was found that feed fluctuated under heavy continuous spring and late fall grazing in accordance with favorable and unfavorable growing conditions during the first 2 years of the period, but because of decreased plant vigor due to overuse the productivity of the pastures declined consistently thereafter in spite of some very favorable years. At the end of the experiment the grazing value had been reduced 20 to 65 percent.[6]

It has been shown experimentally on the Jornada Experimental Range in New Mexico that clipping black grama to a height of 2 inches reduced the forage yield by one-half in 3 or 4 years and practically to zero in 8 or 9 years. Tobosa clipped to 4 inches in height

[3] NELSON, E. W. THE INFLUENCE OF PRECIPITATION AND GRAZING UPON BLACK GRAMA GRASS RANGE. U. S. Dept. Agr. Tech. Bul. 409, 32 pp., illus. 1934.

[4] SAVAGE, D. A., and JACOBSON, L. A. THE KILLING EFFECT OF HEAT AND DROUGHT ON BUFFALO GRASS AND BLUE GRAMA GRASS AT HAYS, KANSAS. Amer. Soc. Agron. Jour. 27: 566-582, illus. 1935.

[5] FLORY, E. L., and TRUSSELL, D. F. PRELIMINARY NOTES ON IMPORTANT VEGETATIVE SPECIES OF REGION 8. U. S. Soil Conserv. Serv., Region 8, Bul. 23, 16 pp., illus. 1938. [Processed.]

[6] CRADDOCK, G. W., and FORSLING, C. L. THE INFLUENCE OF CLIMATE AND GRAZING ON SPRING-FALL SHEEP RANGE IN SOUTHERN IDAHO. U. S. Dept. Agr. Tech. Bul. 600, 43 pp., illus. 1938.

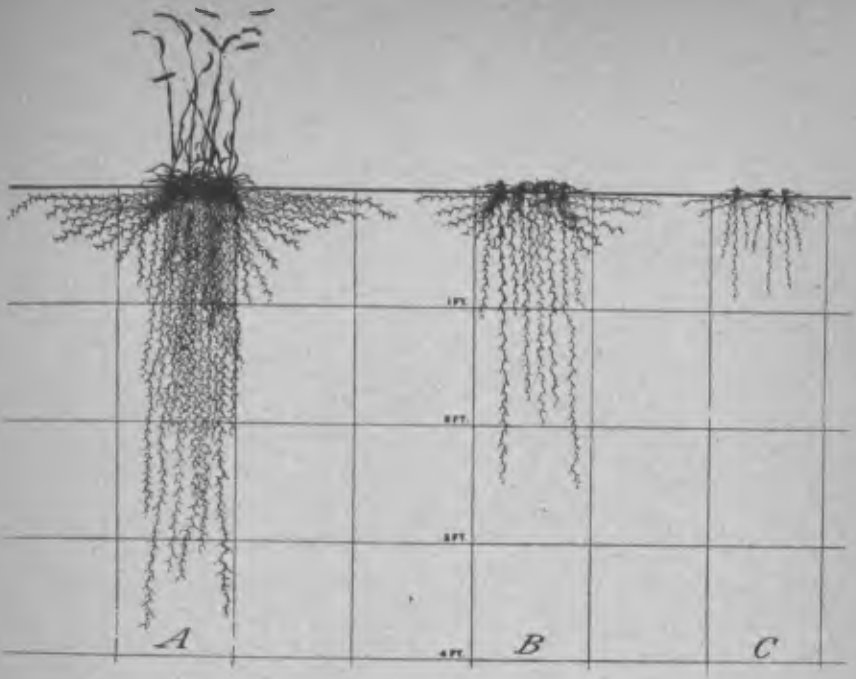

FIGURE 5.—Blue grama plants. *A*, Plant from properly used range, with maximum vigor, root penetration, and forage production. *B*, Plant typical of overused ranges, with low vigor, restricted root systems, and low forage production. Such plants produce little or no seed even in the best years. *C*, Plant from a heavily overgrazed range, with low vigor, greatly reduced root system, and practically no forage production even in the best years.

yielded 110 percent more total forage in the 11-year period from 1924 to 1935 than that clipped to 2 inches. Vigor and stand were so reduced by the 2-inch clipping that the plots clipped to 4 inches yielded 11 times more forage during the last 4 years of the experiment than did the more closely clipped plots.[7]

There is a close correlation between plant cover and penetration of water into the soil. All parts of the grass plant, roots, stems, and leaves play an important part in soil and water conservation, but forage production can be expected only where precipitation penetrates the soil and is protected from surface evaporation. Consequently, any measures that tend to keep moisture where it falls will contribute proportionately to forage production. Recent studies [8] indicate that vegetal debris on the soil surface is the most important factor in reducing runoff and increasing percolation of water into the soil and has a greater effect in reducing runoff than the combined effects of degree of slope, previous moisture content of the soil, and rate of precipitation.

The chief object of range management is to provide for the amount of grass growth and vegetal debris that should be left on the ground

[7] CANFIELD, R. H. THE EFFECT OF INTENSITY AND FREQUENCY OF CLIPPING ON DENSITY AND YIELD OF BLACK GRAMA AND TOBOSA GRASS. U. S. Dept. Agr. Tech. Bul. 681, 32 pp., illus. 1939.

[8] DULEY, F. L., and KELLY, L. L. EFFECT OF SOIL TYPE, SLOPE, AND SURFACE CONDITIONS ON INTAKE OF WATER. Nebr. Agr. Expt. Sta. Res. Bul. 112, 16 pp., illus. 1939.

NM—10880

FIGURE 6.—Full feed on well-managed ranges makes possible the production of big cows and a large crop of heavy calves.

to: (1) Conserve soil and moisture; (2) maintain a stand of desirable plants in vigorous condition; (3) help restore a desirable vegetal cover on depleted and denuded ranges; and (4) maintain maximum forage production, which in turn results in maximum livestock production (fig. 6).

ARTIFICIAL REVEGETATION BY RESEEDING

Artificial revegetation should not generally be attempted on areas where natural recovery of the native cover, under proper management, can be expected within a reasonable length of time. In some instances, seeding may be justified to obtain a more desirable cover than the original stand. In others, depletion may have proceeded so far that artificial means must be resorted to in order to check erosion and take advantage of existing soil conditions before they become so greatly altered that the reestablishment of an effective erosion-resistant cover is no longer possible (fig. 7).

SITES THAT NEED RESEEDING

There are many sites in the Southwest where artificial revegetation may be used as an aid in the control of erosion with reasonable assurance of success. While the primary objective should be the development of a vegetative cover to hold the soil, full consideration should be given to the need for increasing the quantity and quality of forage production and providing food and cover for wildlife. Sites of the following kinds should be analyzed carefully, and species should be selected for planting that are highly useful and best adapted to the soil and other environmental conditions.

FIGURE 7.—A depleted range in Sulphur Springs Valley, Ariz., restored by seeding Lehmann lovegrass in contour furrows.

1. Depleted and denuded range areas where natural soil and moisture conditions will permit the establishment and support of range plants, especially grass and browse species (fig. 8).
2. Abandoned lands, lands of low productivity, and steep slopes should be seeded to permanent cover.
3. Denuded and eroding areas where vegetal cover can be used in conjunction with temporary structures built to hold the water on the land and distribute it over the area. Such structures may consist of percolators and water spreaders constructed of short-lived materials such as brush and wire, and contour furrows, ridges, and dikes. Soil moisture can thus be augmented to the extent that such permanent vegetation can be established as will prolong the life of the structures and eventually replace them with a permanent protective cover.
4. Desilting areas above stock tanks and similar structures where natural recovery of the native cover cannot be expected within a reasonable length of time.
5. Dikes, banks, dams, and spillways, which need a protective vegetal cover to increase their effectiveness and prolong their life (fig. 9).
6. Areas denuded in the construction of highways, roads, trails, pipe lines, railroads, culvert inlets and outlets, and other points of water concentration, cuts, fills, and other critical sites created as a result of construction (fig. 10).
7. Small arroyos and gullies in which plants and seed may be planted to establish vegetation for the protection of the banks against further cutting, to reduce velocity of flash floods, and to serve as vegetative plugs and desiltors that will gradually effect deposition.
8. Sand-dune areas (figs. 1 and 11).

NM-R-60; NM-9451

FIGURE 8.—*A*, A denuded and eroding range near Gallup, N. Mex., seeded to western and crested wheatgrass and put under proper use in 1934; *B*, the same range 3 years later. Livestock grazing capacity had been increased and erosion brought under control.

ARIZ—121

FIGURE 9.—Grass planted on a dam near Solomonville, Ariz., to protect it from erosion.

9. Head cuts capable of being stabilized by vegetation, and areas above and below head cuts on which water is checked and spread. It is preferable that such areas be fenced.

NM—10360

FIGURE 10.—Western wheatgrass established in competition with Russian-thistle 1 year after it was seeded on a cut bank along United States Highway No. 66 near the Continental Divide.

NM–11174

FIGURE 11.—Stabilization of drifting sand by brush windrows preparatory to reseeding. San Ysidro, N. Mex.

THE QUEST FOR ADAPTABLE SPECIES

Native species which have demonstrated their ability to withstand the rigors of western range conditions are safe to use for reseeding under conditions comparable to those under which they occur normally. Certain native species, however, are superior to others for use in range reseeding. Favorable characteristics include the following: (1) High soil-binding value, (2) high production of viable seed that can readily be harvested, cleaned, and planted with machinery suitable for other farm operations, (3) ease of establishment, (4) drought resistance, (5) vigor of seedling habits, (6) ability to spread naturally and readily by seed or vegetative means or both, and (7) production of high yields of palatable, nutritious forage.

Nearly all grass species exhibit extreme variations in growth characteristics and habits (fig. 12). These may be variations between individuals or distinct groups or strains in the same locality, or they may be strains which have developed under different environmental conditions. Strains from high altitudes and northern localities mature relatively early and are usually less vigorous in growth than those coming from lower or southern areas.

Individual plants of the same species may vary in winter hardiness, drought resistance, longevity, seed productivity, size of seed, character of seed, seedling vigor, steminess, leafiness, earliness or lateness of maturity, ability to spread vegetatively, resistance to disease, or even palatability.

As stated before, the Nursery Division, in collaboration with other interested technical divisions of the Soil Conservation Service, and in cooperation with the Bureau of Plant Industry and the State agricul-

FIGURE 12.—Six different strains of blue grama growing in rows at the Soil Conservation Service nursery near Albuquerque, N. Mex. Note differences in length of leaf, amount of forage, and seed production.

tural experiment stations, is working to assemble, test, and increase superior species and strains of grasses, both native and introduced, which are adapted for use in revegetation in the Southwest.

Promising native and introduced species and strains are first assembled and planted for initial observation and study at the nurseries (fig. 13). The original seeds or other propagating materials are

ARIZ 4101

FIGURE 13.—Short rows of native and introduced grasses growing at the Soil Conservation Service nursery at Tucson, Ariz. Various promising grasses are assembled and planted for study and for developing superior strains and species to be used in reseeding depleted southwestern range lands.

obtained from many sources. Some are native species and strains obtained by plant collectors in the Southwest or through exchange with Soil Conservation Service nurseries in neighboring regions having similar climatic and environmental conditions. Others are exotic species obtained through foreign explorations sponsored by the Department of Agriculture for the express purpose of collecting seeds and plants in areas where the climatic factors and environmental conditions are similar to those in this country. Plant materials are also obtained through technicians from other countries who visit Soil Conservation Service nurseries and supply, on an exchange basis, seeds of foreign plants which may have a place in the revegetation program in this country.

Initial experimental plantings are made at the nurseries where ample water is supplied through irrigation. These plantings provide a means of making preliminary determinations of the ability of the species to grow and produce seed under favorable conditions (fig. 14). The various species and strains are also observed for other characteristics, such as vigor, hardiness, ability to spread, and forage value, and potential suitability for erosion control. The most outstanding species and strains are then selected for increase. This provides a source of seed for supplementary trial on problem areas throughout the Southwest Region to determine their adaptability and the best methods of establishment under various climatic and environmental conditions. Some species and strains prove to be suitable as forage grasses in irrigated pastures. Only those grasses which demonstrate from these trials that they can establish themselves and continue to grow and spread under natural conditions are considered to have a place in the range-revegetation program.

ARIZ-3881

FIGURE 14.—A seed-increase planting of weeping lovegrass at the Soil Conservation Service nursery, Tucson, Ariz., showing the adaptability of this grass to farm-seed production under irrigation.

Species and strains which have proved through trials on problem areas to be of practical use in pasture and range plantings and have also shown through their performance on the nurseries that they can produce seed successfully and economically as a farm crop, are then ready for quantity increase of seed for extensive use in revegetation plantings.

Limited amounts of these seeds can be released to the cooperating State agricultural experiment stations for distribution to farmers in accordance with the experiment stations' policy of placing improved strains of seeds with competent cooperators for increase. The successful use of these species in revegetation plantings ordinarily results in an early increase in demand for such seeds.

HARVESTING SEED FROM NATIVE STANDS

Until superior strains of native grasses are developed and an adequate commercial seed supply of proven introductions is produced, much of the increasing demand for seed for range revegetation must be met by harvesting from native grass stands. A few ranchers are supplementing their income by harvesting seed of gramas, wheatgrasses, dropseeds, and others from native stands. Individuals should have little difficulty in finding a market for native grass seeds adapted to range reseeding. If several collectors in a vicinity pool their seed in a cooperative association it would no doubt facilitate the locating of markets through Federal and State agencies, commercial seed houses, State soil conservation districts, and farm organizations.

Various methods have been employed by the Soil Conservation Service for harvesting grass seed from native stands. Hand strippers and grass hooks have been used for collection by hand, and harvesting machinery, such as bluegrass strippers (fig. 15), power strippers, mowers, mower bunchers, and grain binders (fig. 16) are now used for collections on a large scale. Seed so harvested needs additional threshing and cleaning. The first use of bluegrass strippers for harvesting blue grama seed from native stands was made by C. P. Wilson, near Estancia, N. Mex., in 1930.[9]

Seed harvested by the small rub-bar type of grain combine, which has rubber-faced cylinder bars and concaves, contains less trashy material as it comes from the machine and is obtained at a lower cost than seed gathered by any other method so far used (fig. 17). Native seed is found in many locations that are rough or have small trees or other obstructions. Small combines can ordinarily be used in such locations where larger outfits would be unmanageable.

Collecting native grass seed is a process requiring meticulous care. No rule-of-thumb statement can be made as to the number of good seeds a grass seed head or spike should contain to warrant harvesting. This would depend upon several factors such as the kind of grass to be harvested, the cost of recleaning or processing the bulk material collected, and the contemplated subsequent use of the harvested material. It may be practical for a rancher to collect native grass seed from good stands of grass on his range to be used for broadcast planting on other parts of his range needing reseeding even if the bulk material har-

[9] WILSON, C. P. THE ARTIFICIAL RESEEDING OF NEW MEXICO RANGES. N. Mex. Agr. Expt. Sta. Bul. 189, 37 pp., illus. 1931.

vested contains only a small percentage of good seed. If the seed is to be marketed, however, a reasonable percentage of purity is desirable.

Harvesting native grass seed must proceed rapidly and at the proper time. In some species, the seed matures over a prolonged period, and the earliest seeds to mature may shatter out while others in the same seed head are still too green for harvesting. Such seeds should be collected at the time when the most mature seed is still in the heads.

NM -8796

FIGURE 15.—Soil Conservation Service nursery seed collector harvesting seed of alkali sacaton with grass strippers from a native stand near Roswell, N. Mex.

ARIZ—1244

FIGURE 16.—Harvesting mountain brome seed with a binder near Flagstaff, Ariz.

Although a good crop of seed heads may be produced, they may contain only a small number of good, plump seeds. Seed heads may not be filled, or the seed may shatter out very soon after ripening. Periodic examinations should be made to be sure that empty hulls are not being collected.

As an aid in determining the number of good seeds in seed heads from a stand of native grass, a small rubbing board and rubbing block can be used. These can be made by tacking corrugated rubber

NM–11885

FIGURE 17.—Soil Conservation Service nursery seed collector harvesting seed of galleta grass with a small combine from a native stand near Tucumcari, N. Mex.

matting on one side of a small flat board and around three sides of a 2- by 4-inch block about 6 inches long. Mature representative seed heads should be collected from several places in the area to be harvested and the seed separated from the chaff by placing the heads on the board and rubbing them with the block. It is also possible to count the seed in the seed heads of many grasses such as blue grama by clipping along the heads through the spikelets and counting the good seeds. These can be seen with the aid of a hand lens.

GRAZING CONTROL AND RODENT CONTROL

Artificial revegetation should not be attempted unless the young seedlings, through livestock and range management, can be assured adequate protection against grazing and trampling until they are established sufficiently to withstand normal usage without damage. Grass seedlings grow very slowly the first year. It is important, therefore, to protect them during this period of establishment. The first use after revegetation planting should be limited to dormant periods, and in succeeding years it is necessary to manage grazing so that the stand will be maintained at a high production level. *It is*

useless to attempt range restoration as long as the period of grazing and degree of use which depleted the range in the first place are continued. Restoration of ranges by any means can be effective only when efforts to that end are accompanied by proper range management.

When numerous, rabbits, Wyoming ground squirrels, and prairie dogs are a serious handicap to the reestablishment of a forage cover; if such conditions are definitely known to exist, provision for rodent control may be necessary. Control of rabbits is difficult and expensive and under most conditions is not practical. Advice on proper methods for controlling Wyoming ground squirrels and prairie dogs should be obtained from the Fish and Wildlife Service or Grazing Service of the Department of the Interior, the county agent, or the Soil Conservation Service.

TIME OF SEEDING

The proper time of seeding will vary considerably in different parts of the Southwest. Gramas, galleta, tobosa, curly mesquite, and other associated summer-growing species that need warmth for ready germination occupy areas where high temperatures and adequate soil moisture occur simultaneously. Such areas are further characterized by slight winter-spring precipitation, a very dry early summer, and a period from July to early fall during which the major portion of the year's precipitation occurs.

In such locations, Soil Conservation Service nursery supplementary trials have shown that grasses should be seeded between June 15 and July 30, just before or during the early part of the rainy season. However, even when heavy rains occur rather early, seedings made at the beginning of this 45-day period may fail if the rain is followed by hot drying weather with no subsequent moisture. Grass seedlings may start, but the soil will dry out faster than the small seedlings can extend their root systems below the drying soil layers. Seedings made about July 15 will commonly have the best chance of succeeding since the young plants then will have favorable growing conditions long enough to give them sufficient size, vigor, and root systems to carry them through the next year's early summer drought. At any other season seeding will have little chance of success because the seedlings will not be established well enough to withstand the early summer drought. Delayed germination, caused by lack of the high temperatures required by the species adapted to this habitat, contributes to the failure of late fall and spring seedings.

The wheatgrasses, ryegrasses, bromes, fescues, and other fall- or spring-growing grasses occupy areas on which there are relatively heavy winter snows and early spring rains. These grasses generally should be seeded in the fall and early spring as they germinate under relatively low temperatures at a time of year when there is adequate soil moisture.

Seed planted in late fall will generally remain dormant in the soil during the winter and germinate during the first warm days of spring while the soil is still moist from melting snows. At this time of year the soil will remain moist for a relatively long period and insure the establishment of seedings before the dry summer season arrives. Seed planted in late fall usually will germinate 2 weeks or more before spring seedings can be made. The spring seeding period is very short, and it is difficult to make broad-scale seedings in the few days when soil-moisture conditions are right. Spring seeding, to be

successful, must be done early enough to take advantage of moisture from melting snow and early rains, although the soil is usually too wet to be worked at this time.

Areas in which there is a period of relatively heavy precipitation in summer and another in winter are characterized by a mixture of fall- or spring-growing and summer-growing grasses. In these, seeding may be successful from July until late fall, but none of the summer-growing species should be included in the seeding mixture after September 1.

SOIL MOISTURE

In areas to which fall- and spring-growing grasses are adapted, where dry farming has been practiced, soil moisture generally is adequate for successful artificial revegetation by solid seedings. Although the methods of soil preparation ordinarily practiced for dry-farm seeding operations commonly is satisfactory, additional pains taken to augment the normal soil moisture by conservation methods will increase the possibility of success and will tend to increase yields.

In areas to which summer-growing grasses are adapted, additional soil moisture provided by means of furrows, ditches, dikes, terraces, ridges, percolators, and spreaders will aid materially in establishing a stand. These structures are an absolute necessity in many of the more arid situations (fig. 7). Litter has been very beneficial in facilitating the establishment of young seedlings in the more arid locations. It aids in maintaining moisture in the surface soil, shading the tender seedlings from full sunlight and protecting them from direct wind. Straw containing a large amount of seed of adapted species may be used effectively on exposed areas such as dams, stock tanks, and dikes. This practice is rather expensive, however, but is justified on areas that are particularly critical, especially where the source of mulching material is close at hand.

WEED COMPETITION

Denuded grasslands naturally return to a stand of good forage grasses through successive stages of weeds and pioneer grasses. This process may, however, take several decades. Final recovery is delayed by active and continued competition from the weeds and scarcity of grass seed. It may be hastened by the planting of grass seed, but much of the seed is wasted in a soil heavily infested with weeds or with weed seeds that are partially germinated or dormant. Weeds that germinate and grow at the same season as the seeded grasses compete for soil moisture, impairing the survival and establishment of the grass seedlings.

In the case of summer-growing species of grasses, the weeds that have emerged or germinated partially are most easily destroyed after the first summer rains by the tillage incident to seeding.

In the areas where the fall- or spring-growing grasses dominate, grass may be established successfully by drilling the seed in a Russian-thistle or similar weed cover. These grasses, in contrast to the summer-growing grasses, are capable of emerging after weeds have stopped growth in the fall and before they have renewed growth in the spring. Even with these types of grasses better results are obtained in clean stubble or clean fallow fields.

Such winter annuals as downy chess (*Bromus tectorum*) offer severe competition to the fall- or spring-growing grasses since they germinate

and grow at the same time and under the same conditions. Downy chess grows much faster than the perennial grasses, and if the desirable species are to be established successfully it is essential that the "weedy" grass be destroyed or its competition materially lessened. Late fall tillage and seeding operations will kill most of the downy chess which has germinated.

NURSE CROPS

Nurse crops affect newly seeded grass stands in the same manner as weeds, using moisture that is badly needed by the young grass seedlings. Where moisture is the limiting factor grasses undoubtedly do better without a nurse crop since the annuals used for nurse crops start quicker and grow faster than the grass and use most of the available moisture. If there is insufficient moisture for both, the grass and not the nurse crop will be the one to suffer. Even when there is plenty of moisture for both, the nurse crop may soon overshadow the grass, and instead of stooling out, the grass becomes weak and slender in its attempt to reach the light. In the early summer, when the previously weakened grass plant particularly needs moisture, a major portion of the available moisture goes to mature the annuals constituting the nurse crop. As a result, most of the grass dies.

PREPARATORY COVER CROPS

Noncompetitive cover crops grown prior to seeding grass have been found to be very helpful in establishing grass stands in the Great Plains.[10] This practice, however, has not been employed to any extent west of the Great Plains in the area under discussion in this bulletin, but in areas where there is sufficient precipitation to produce a satisfactory growth of Sudan grass, cane sorghums, and similar preparatory crops for stubble mulch the use of such noncompetitive cover crops would assist in the establishment of grass stands, especially in areas subject to wind erosion.

SEED MIXTURES

A mixture of forage species is generally preferable to a pure stand of any one species. Different species grow at different seasons of the year and absorb moisture and nutrients from more or less distinct soil levels. Hence they profit somewhat by association with each other, while plants of the same species are in direct competition. A mixture, therefore, will have a longer growing season and will produce a larger quantity and a greater variety of forage. Forage species also vary in their seedling vigor, seedling size, mature size, rapidity of establishment, persistency of stand, and soil and moisture requirements. Consequently a mixture of seed will produce a quicker stand, a more permanent cover, and a more productive range than a single species. The proportion of seed of the various species to be used in a mixture should be based upon the purity, viability, and size of the seed; the size of the mature plants; and the adaptability of each species to the particular situation.

The introduction of an efficient legume into the seed mixture is regarded as one of the basic principles of grassland and soil improve-

[10] SAVAGE, D. A. GRASS CULTURE AND RANGE IMPROVEMENT IN THE CENTRAL AND SOUTHERN GREAT PLAINS. U. S. Dept. Agr. Cir. 491, 56 pp., illus. 1939.

ment. To be of most value in this connection, a legume should be herbaceous, edible, and palatable; it also needs to be aggressive and able to withstand grazing. Unfortunately, no seeds of legumes that can be used in summer-growing grass areas in the Southwest are available, and only sweetclover and alfalfa are now available for fall- or spring-growing grass areas. It is possible that suitable species may be developed as the result of extensive nursery tests of native and introduced legumes now being made.

QUALITY OF SEED

Grass seed varies considerably in quality. The quality of the bulk planting material of many range species is especially variable and often very poor. Such material may contain seed that will not germinate, broken seed, weed seed, beards, shucks, hulls, straw, chaff, and other foreign material. Bulk planting material of many light, fluffy species, is difficult to clean and may contain as little as 5 percent pure seed; others having naked heavy seed, which is easy to clean, may have as much as 95 percent pure seed. Of the pure seed the proportion that will grow may be as little as 10 percent in some species and as much as 95 percent in others. The quality of the seed of different grasses will be discussed later under the treatment of various species.

Seed should bear a label identifying the planting material by name and stating the place where the seed was harvested, the percent of pure seed of the kind desired (purity), the percent of germination, and the names and amounts of weed or other foreign seeds. For example, the label on a good quality of blue grama seed might show "purity 40%," "germination 80%." A good quality of crested wheatgrass seed might show "purity 90%," "germination 90%." In either case the kind and amount of foreign matter should also be shown.

Blue grama seed labeled as indicated would mean that in every 100 pounds of bulk planting material there would be 60 pounds of inert material and only 40 pounds of pure grama seed. Since only 80 percent of the pure grama seed is viable, only 32 pounds of each 100 pounds bulk planting material would be "live, pure" grama seed that could be expected to grow. The "live, pure" seed of range species may constitute from less than 1 percent to more than 95 percent of bulk planting material.

RATE OF SEEDING

The amount of seed to be used per acre depends upon such factors as quality of seed, size of seed, and character of the plants themselves. Generally about 30 "live, pure" seeds per square foot are necessary to establish an adequate stand, but some of the species that start quickly and grow vigorously can be sown at a slightly lower rate. Conversely, some of the small-seeded species having small, weak seedlings which are slow to become established require a higher rate.

Adapted species having a large number of small seed per pound may be used with other species having a small number of large seed per pound to reduce the rate of seeding per acre as well as the expense of seeding. For example, both western wheatgrass and sand dropseed are adapted to many situations. The former has about 128,000 seed per pound, about 60 percent of which, or 72,000, may be "live, pure" seed. Used alone, it would require about 20 pounds per acre to provide 30 live seeds per square foot. Sand dropseed has about

5,400,000 seed per pound, of which about 3,500,000 may be "live, pure" seed. It is apparent that a small amount of dropseed would materially decrease the amount of wheatgrass seed necessary. The rate of seeding cannot be calculated exactly on this basis, however, as grass plants vary in seedling vigor, size, persistency, and ability to spread naturally. The wheatgrass is much more desirable and spreads very vigorously from underground rootstocks, and less than 30 seeds per square foot may, therefore, suffice. On the other hand, it is relatively slow in becoming established and another species is necessary to provide a ground cover during its period of establishment. For this purpose sand dropseed does very well, but because of the small size of its seed and small seedlings, more than 30 seeds per square foot will be required. Many native grasses have hard seed which do not show maximum germination and full stands until the end of the second growing season.

DEPTH OF SEEDING

Gardeners have an old rule which says, "Seeds should be sown at a depth three times their own thickness," and although not literally correct, the inference of the rule holds good—small seeds must be sown at a very shallow depth, while larger ones can be planted deeper. Small seeds have thin, weak shoots, generally incapable of forcing their way readily through a deep layer of soil, especially if the soil is heavy or inclined to crust on the surface following a rain. As the seeds of most range grasses are small, it is essential to their success in emerging that they be covered by a shallow layer of soil. For practically all grass seeds, the depth should not exceed three-quarters of an inch, and for the great majority a still shallower depth is preferable, except on light soils where dry, windy conditions prevail and the surface soil is apt to dry quickly to a depth below the shallow planting. When seed is sown in mixture, which usually is the case, the depth of seeding should be regulated for the smallest seeds in the mixture. An appreciable proportion of the failures to secure revegetation are due to seed being covered too deeply. Such planting may be the result of too loose a seedbed, broadcasting on the surface and disking too deeply, or seeding in the bottom of furrows in which silt subsequently collects.

SEEDING OPERATIONS

Range areas needing revegetation in the Southwest present diverse conditions which must be given consideration in the development of seeding operations. Some of the principles to be considered in seeding are economy of the operation, proper preparation of the seedbed, placing seed at the right depth in the soil, and the use of planting equipment which will handle the various kinds of seed in mixtures.

Much work has been done both in developing and adapting machinery for handling various types of grass seeds under the different situations encountered. Common grain drills provided with seed-box agitators successfully plant the wheatgrasses, ryegrasses, bromes, ricegrass, and other large-seeded grasses which can be well cleaned. Drilling gives an even distribution of the seed, places seed at uniform and proper depths, and saves time and seed. With an alfalfa or fine grass-seed attachment, dropseeds, lovegrasses, clovers, and other small, clean-seeded species may be planted with a grain drill at the same time the larger seeded species are planted.

Where drilling is done in an undisturbed annual-weed cover, deep-furrow drills have proved superior because the weeds are destroyed in a strip on both sides of the drilled seed. Another advantage is that seedlings in the bottom of a furrow are not subjected to drought injury as much as are those on the surface. During excessive rains there is danger, however, that seedlings in the deep furrows will be covered by silt and killed. A seeding attachment recently developed for use on a lister incorporates the advantages of the deep-furrow drill and corrects the disadvantages (fig. 18, *A*).

The mechanism of the ordinary grain drill has proved inadequate to handle mixtures of the trashy, light, fluffy seeds characteristic of many of the summer-growing native grasses of the Southwest. Substituting standard combination corn and cottonseed boxes for the regular grain boxes and their feeding mechanism provides a drill that will handle nearly all types and mixtures of seed (fig. 18, *B*). Sometimes, however, very fine seed will settle out of the mixture. This difficulty can be remedied by the addition of an alfalfa or fine grass-seed attachment to the drill.

Drilling grass seed on depleted ranges where hummocks, rodent mounds, depressions, spots of loose fluffy soil, and spots of hard compact soil are encountered is extremely difficult. Under these conditions, ordinary grain drills cover seed too deeply in some places and not at all in others. A double-disk furrow opener is most effective in hard soil. With it seed can be planted uniformly at a desired depth if a strip of steel ¼ inch by 1 inch is welded edgewise on the outside surface of the disks, at a distance from the cutting edge equal to the planting depth desired (fig. 19). This flange will prevent the furrow openers from penetrating more than the desired depth in soft soil, and there is adequate spring pressure to force the furrow opener deep enough into hard soils and depressions. Adjustable depth gages, which can be attached to the disk, are available for use in this connection.

Seed has been sown evenly, rapidly, and economically by broadcasting it from an airplane, but this practice is not recommended unless the seed can be properly covered by some means after being sown.

Modified crank dusters have given excellent service in distributing seed uniformly over the narrow strips of contour furrows, ridges, and dikes and on very rough or brushy land where seed must be broadcast. Seed sown on rough, freshly broken surfaces, is usually covered adequately by the natural settling of the soil. In other cases, seed has been covered satisfactorily by dragging a light piece of brush behind a duster, the seed being distributed and covered in one operation. In small gullies, truck chains have been effectively used in covering seed (fig. 20). In very rough areas the cost of hand raking may be justified. The use of a brush harrow, trampling by sheep, and depending on freezing and thawing to cover the seed are not generally recommended in intensive revegetation programs on lands that are potentially capable of good forage production. Successful stands are uncertain if such methods are used, although on some areas these methods may be of value where conditions do not warrant the expenditure of funds for an intensive reseeding program.

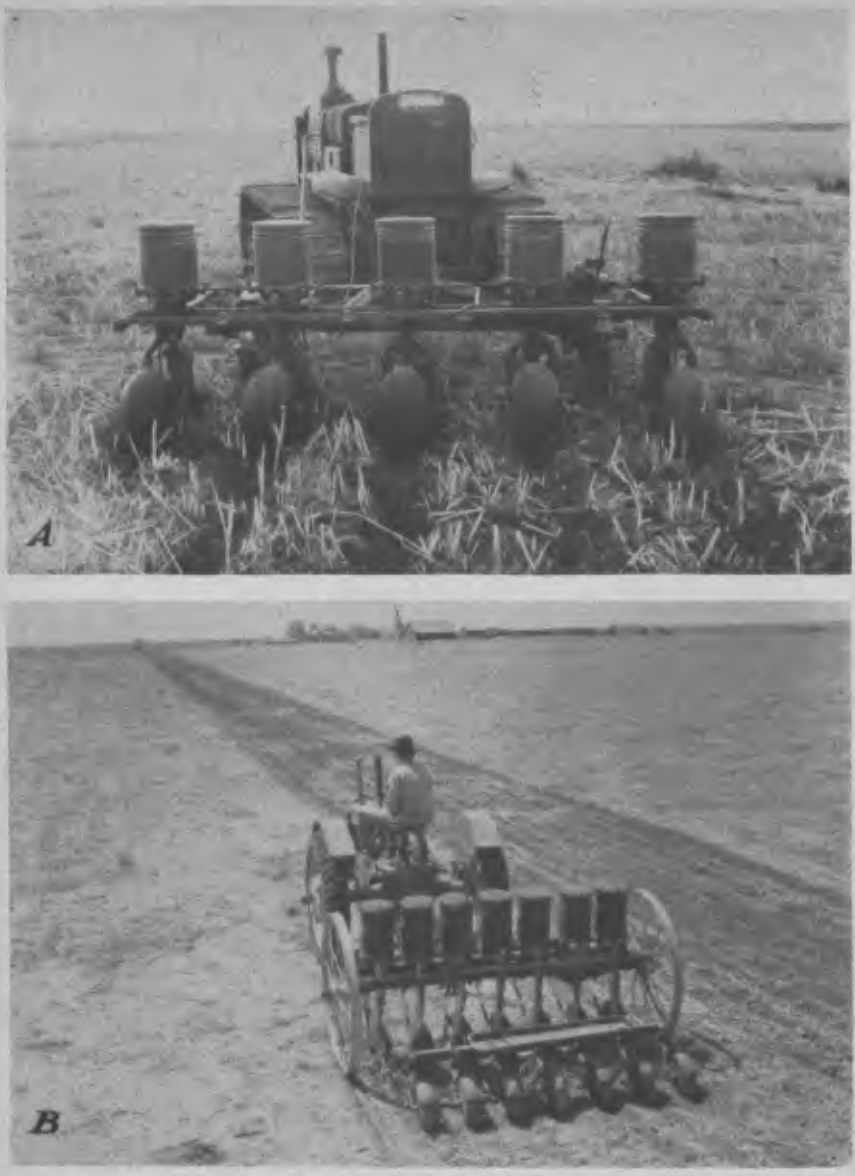

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FIGURE 18.—Combination corn and cottonseed boxes. *A*, Mounted on a lister. A row of grass seed is drilled in each side of the furrow about one-third of the distance from the bottom. The seed is pressed into the side of the furrow by the press wheels. Seed planted here will benefit from collected water and will not be covered too deeply by siltation. *B*, Mounted on a regular grain-drill frame. This modified drill plants chaffy grass seed, which a regular drill will not handle.

FIGURE 19.—Double-disk furrow opener with flanges to prevent grass seed from being planted too deeply.

FIGURE 20.—Covering seed broadcast in small gullies by dragging a truck chain. Cuba, N. Mex.

INDIVIDUAL GRASS SPECIES

For successful reseeding, the individual characters and properties of individual species should be given careful consideration. The methods described in general terms in the preceding discussion should be applied in such a manner as will permit the most effective results in view of the requirements of the individual species. The following discussion presents some of the pertinent information relative to seeding habits, soil adaptability, forage value, and other data now available in this connection.

WHEATGRASSES

The wheatgrasses (*Agropyron* sp.), among the most important forage species of the fall- or spring-growing grasses, occur where an appreciable portion of the year's precipitation is in the form of winter snow. Under favorable conditions, some species produce good yields of hay. Many are pioneer species, being adapted to raw, eroded soils; others have a high tolerance for alkali. Where winter and spring moisture is adequate, it is best to sow wheatgrasses in the fall or in early spring. In localities where they are associated with summer-growing grasses western and crested wheatgrass may also be sown in midsummer.

Crested Wheatgrass

Crested wheatgrass (*Agropyron cristatum* (L) Gaertn.) (fig. 21), a native of the cold dry regions of northern Europe and Asia, is a tufted perennial with a finely branched root system penetrating to a depth of 7 feet. For spring and fall grazing, it is an excellent grass as it begins to grow very early in the spring, responds quickly to moisture after drought periods, and will grow under the snow and in mild winters. The green growth is very palatable and nutritious, and good yields of forage are produced under seemingly adverse conditions. It is more resistant to both cold and drought than western wheatgrass and is successful on all soils except clays and coarse sands. Its range, with a minimum of 10 inches of annual precipitation, is 5,500 to 8,000 feet elevation in New Mexico and Arizona and 4,500 to 7,500 feet elevation in Colorado and Utah (fig. 22).

Seed.—Crested wheatgrass produces from 100 to 900 pounds of seed per acre. Seed can be harvested readily with a combine and can be planted with common farm-seeding machinery. Each pound averages about 235,000 seed, of which 190,000 are usually "live, pure" seed. For seed production, 2½ pounds per acre should be planted in rows 30 to 36 inches apart and cultivated.

Establishment.—For range planting about 10 pounds per acre of average-quality bulk planting material should be broadcast or close-drilled in a firm, well-prepared seedbed as near one-half inch in depth as possible. Although this grass may be established successfully in a Russian-thistle cover, it will grow more rapidly and satisfactorily if

FIGURE 21.—An irrigated seed-increase planting of crested wheatgrass at the Soil Conservation Service nursery, Shiprock, N. Mex.

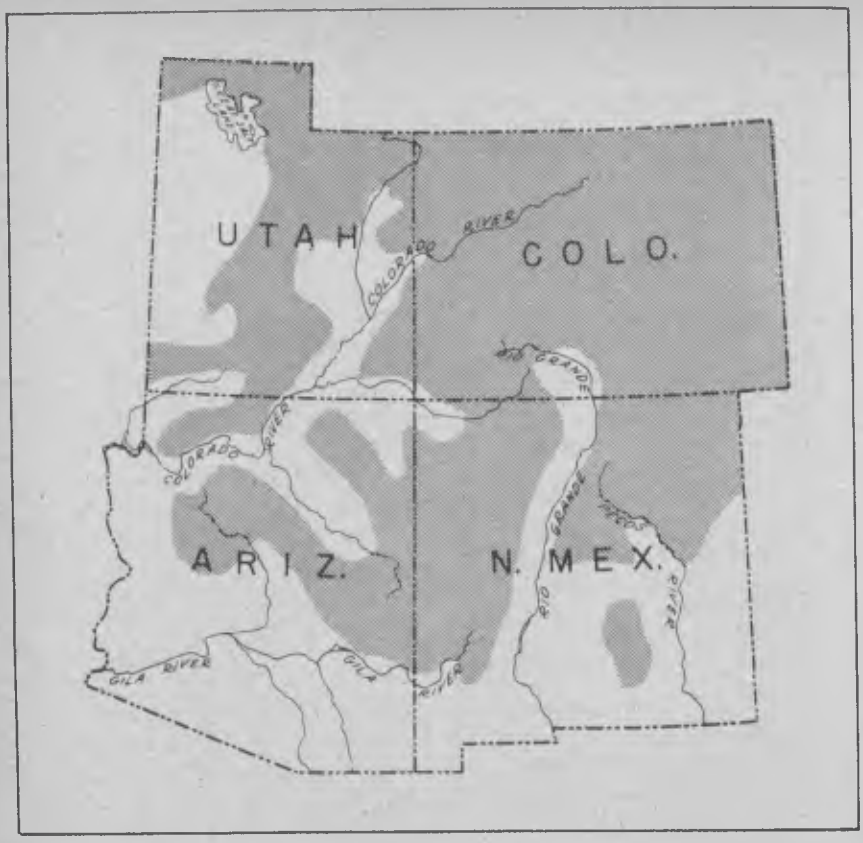

FIGURE 22.—These intermountain and southwestern areas (shaded part of map) have been found suitable for range reseeding with crested and western wheatgrasses.

such weeds are destroyed. New seedlings are small, grow rather slowly, and may require 3 years to attain full development, but once the plants are established, they are very persistent. Where conditions have been favorable, the results with this species have equaled those with any other used in range reseeding.

Availability of seed.—Seed may be obtained through commercial channels at a reasonable price.

Western Wheatgrass

Of all the wheatgrasses in the Southwest, western wheatgrass (*Agropyron smithii* Rydb.), a deep-rooted perennial with creeping rootstocks, is the most abundant. Under most conditions, it forms an open sod, but in the more favorable sites it may form a dense sod. Growth begins early in the spring and continues until early summer; the volume of growth produced in late summer and fall is dependent upon the amount of moisture received during the summer rainy season. The species is resistant to drought but rarely occurs in areas having as little as 10 inches annual precipitation. As an invader or pioneer species, it commonly is associated with blue grama and galleta

grass on disturbed and depleted areas. It is one of the chief grasses in sagebrush areas, except in the Great Basin in Utah where annual precipitation is below 10 inches. Being tolerant to slight concentrations of alkali, it is mixed with galleta to form borders around alkali sacaton areas. It occurs on soils ranging in texture from clay loams to sands, being more common on the finer textured soils. While green, the forage is succulent and palatable, making excellent grazing in the spring and after the summer rains.

Seed.—Seed production is erratic. Low yields of seed are generally produced in the southern part of its range, whereas in favorable years high yields are produced farther north. Seed, which may be harvested with a combine, averages about 128,000 seeds per pound of bulk material, with 70,000 "live, pure" seeds per pound.

Establishment.—About 12 pounds of average-quality bulk planting material should be planted per acre. A stand can be established

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FIGURE 23.—A new stand of western wheatgrass after the second growing season. Floodwaters were retarded and spread over the area by the contour furrows nearly hidden by the grass. Coolidge, N. Mex.

successfully in Russian-thistle cover, but better results can be obtained on a firm, well-prepared seedbed. The new seedlings are small and inconspicuous; consequently the stand usually appears disappointing during the first year, but it improves rapidly in vigor and density after the second year (fig. 23). The tendency of this species to spread vigorously by rootstocks will enable a relatively thin stand to cover the surface rapidly and thoroughly if the plants are protected from grazing until they are well established and the rootstocks have developed.

Use.—In the area described as its natural range, western wheatgrass is useful for general range seedings and the seeding of outlets, borrow pits, dikes, dams, furrows, and gullies. Being a pioneer grass, it succeeds well on eroded raw soils.

Availability of seed.—An adequate supply of commercial seed from northern sources is available at a reasonable price. Seed suitable for use in the area under discussion in this bulletin has been harvested during recent favorable seasons in quantities from areas in northeastern New Mexico and northern Texas and is better adapted for use in the Southwest than seed from northern sources. Rather than retard the seeding program in the Southwest, it is desirable that if adequate seed from southern sources is not available, northern seed be used pending the development of a suitable supply farther south.

Slender Wheatgrass

Slender wheatgrass (*Agropyron trachycaulun* (Link) Malte) is similar to crested wheatgrass in many respects but is not so drought-resistant. It is a relatively short-lived perennial which yields well from about the third to the fifth year after seeding, its productiveness usually declining rapidly thereafter. Being native to a zone extending from oak brush up to spruce and fir, it occurs in dry mountain meadows, along mountain valleys, and in moist, well-drained loamy soils. An annual precipitation of about 14 inches is near the lower limit of its occurrence. Generally it is less leafy and smaller than other wheatgrasses. The species has rather high palatability the year round for all kinds of livestock but not as high forage or seed yield as crested wheatgrass or smooth brome, both of which will thrive on less moisture and poorer soil. Although slender wheatgrass may be used to some advantage in a range reseeding program when it is adapted to the area, this grass should probably never be seeded alone and should constitute only a small portion of a grass mixture.

Seed.—The seed is produced commercially and is handled readily by farm-seeding machinery. It averages about 160,000 seeds per pound, of which 130,000 are "live, pure" seeds.

Establishment.—If slender wheatgrass is to be seeded alone, 12 pounds of average-quality seed per acre should be planted one-half inch deep in a firm, well-prepared seedbed. As it should generally be used in mixtures with other grasses this rate should be greatly reduced to allow adequate space for the growth of more permanent grasses. It also can be established in Russian-thistle cover, though with less success than western or crested wheatgrass. Crested wheatgrass, western wheatgrass, and smooth brome all have been found superior to slender wheatgrass in case of establishment, persistency of stand, drought resistance, and yield of seed and forage.

Bluebunch Wheatgrass

Bluebunch wheatgrass (*Agropyron spicatum* (Pursh) Scribn. and Smith), an important native grass in central Utah where there is heavy winter precipitation, is well adapted to eroded soils and steep slopes and is distinctly drought- and cold-resistant. Its bunch habit does not make it as effective an erosion-control plant as some of the sod grasses, but its deep, finely branched root system makes it a satisfactory soil binder on sites where sod-forming grasses cannot be established. The species is variable in leaf width, amount of basal foliage, seed production, fall and spring recovery, height, and date of maturity. Its palatability is very good to excellent in spring, summer, and fall. Forage a year or more old is tough and is not relished.

Seed.—Because of the beards, the seed is rather difficult to harvest, clean, and plant. Yields from native stands are uncertain and spasmodic.

Quackgrass

Quackgrass (*Agropyron repens* (L.) Beauv.) is considered a pest on farm lands because of its very aggressive rootstocks, but this characteristic, coupled with its fair forage value, makes it highly valuable for erosion control. It requires fairly moist soil but withstands drought well. The rate of seeding is 15 pounds per acre.

GRAMAS

The gramas are summer-growing grasses. Perennial species are commonly high in palatability and erosion-control value. They are the chief range grasses where the major portion of the year's precipitation occurs in the hot months of July and August (fig. 24), and should be planted immediately preceding or preferably soon after the beginning of the summer rainy season. Although spring seeding of gramas is desirable in the Great Plains and the extreme eastern portion of the area under discussion in this bulletin, early spring and fall plantings generally have proved unsuccessful farther west. Seed planted at these times will not germinate until the soil becomes fairly warm, and as the seedlings of these species grow rather slowly, the young seedlings do not become sufficiently established to survive the early summer drought. Most gramas are climax species and require favorable soil conditions for establishment; commonly they are not alkali-resistant. All are small-seeded and should never be planted more than one-half inch deep.

Blue Grama

Blue grama (*Bouteloua gracilis* (H. B. K.) Lag.) (front cover) is too well known to warrant any lengthy discussion of its habits and distribution. It is a perennial, densely rooted short grass which spreads by tillering and in favorable years by seed. It persists under relatively close grazing. Large areas formerly characterized by a mixture of tall and short grasses are now practically pure blue grama stands, the taller species, unable to persist under close use, having been killed out. Blue grama is one of the most palatable grasses and is readily eaten at all stages of maturity. Numerous variations occur in this species, many of which are being observed at the Soil Conservation Service

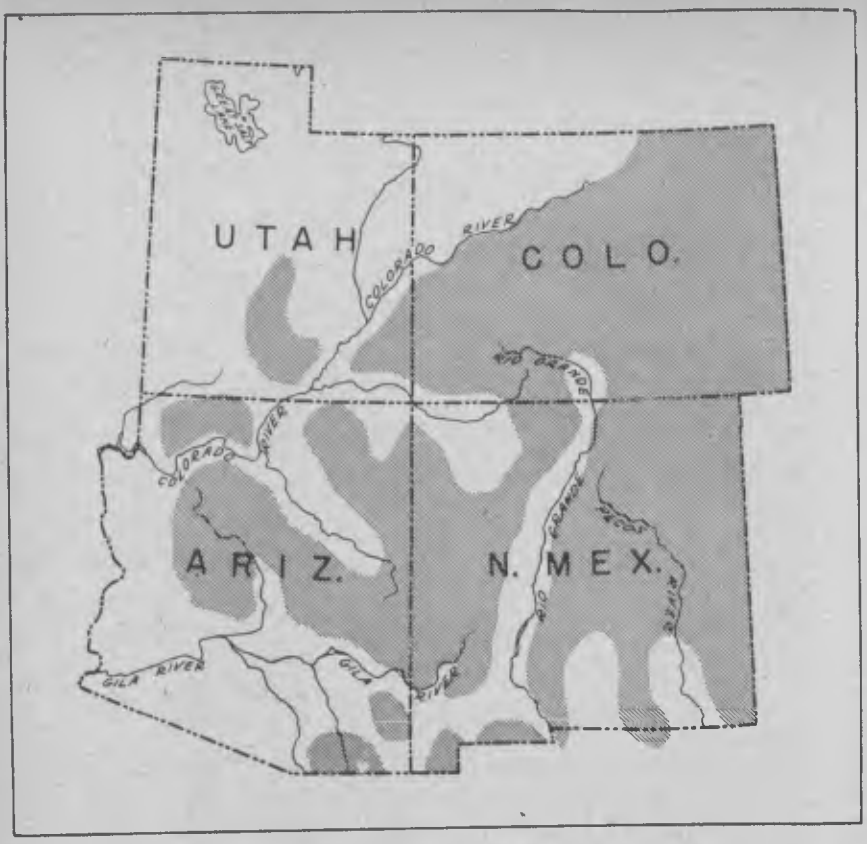

FIGURE 24.—These intermountain and southwestern areas (shaded) have been found suitable for range reseeding with blue grama and side-oats grama.

nurseries in order that superior forage strains with vigorous seedling habits may be developed (fig. 12).

Seed.—Blue grama seed is collected from native stands. Trashy seed obtained by stripping, threshing, and other means of harvesting has been found difficult to plant successfully. Seed fairly free of straw and trash is now being harvested by the small combines previously described. In order to obtain an adequate supply of seed, it is ordinarily necessary to begin harvesting before seed is in the best condition. The first and last collections need to be run through the combine a second time for additional cleaning. Bulk planting material of high quality averages about 800,000 seeds per pound, with 600,000 "live, pure" seeds per pound. Highest range yields may reach 200 pounds an acre.

Establishment.—For pure grama seedlings, 15 to 20 pounds per acre of average quality bulk planting material is necessary. Since seedlings are slow in becoming established, other perennial species should be mixed with blue grama to establish a ground cover and furnish some forage as quickly as possible.

Use.—In its natural range, blue grama is most useful in reseeding depleted ranges where soil conditions are still favorable. It does not

commonly do well on raw, eroded soils or on the subsoil of fresh cuts and fills.

Availability of seed.—Seed is now being collected for sale by commercial seed companies. Ranchers generally can collect seed for their own use from native stands.

Side-oats Grama

Side-oats grama (*Bouteloua curtipendula* (Michx.) Torr.) is an erect perennial grass with a deep fibrous root system found in every part of the United States except the extreme Northwest. It is drought-resistant and winter-hardy. It propagates by seed and short, scaly rootstocks. In spite of its rootstocks, it usually is tufted in habit like the bunchgrasses. It seldom occurs in pure stands, being commonly found in mixture with other grasses. It is relished by all kinds of livestock, either as hay or pasture forage. Unable to withstand as close grazing as blue grama and other short grasses, with which it is commonly associated, it has been eliminated from many ranges where it once was common. The inability of livestock to graze it closely on steep and rocky slopes accounts for its relative abundance in such locations. The grass is sometimes called "side-hill" grama.

Seed.—Collection of pure seed from native stands of this species in the Southwest is not practical because of its habit of growing in mixture with other grasses. The steepness and rockiness of the slopes on which the species ordinarily grows makes the use of seed-harvesting machinery impossible. It is, however, one of the native grasses most adaptable to farm cultivation for seed production because of its erect habit and good production of readily harvested seed (fig. 25). The combination corn and cottonseed drill will handle the seed with little difficulty although seeding operations are considerably facilitated if the seed has been processed with a hammer mill. On sites where

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FIGURE 25.—A seed-increase planting of side-oats grama at the Soil Conservation Service nursery, Pima, Ariz., showing the adaptability of this grass to farm seed production under irrigation.

machinery can be operated the seed can be harvested by a combine. Seed yields of over 400 pounds per acre have been secured under cultivation. Pure seed will average 190,000 seeds to the pound, but generally a pound of bulk planting material will average only about 40,000 "live, pure" seeds.

Establishment.—Seed should be drilled in at the rate of about 20 pounds per acre of average-quality bulk planting material for solid range plantings and at the rate of 3 pounds per acre in rows 30 to 36 inches apart in a firm, well-prepared seedbed for seed production under cultivation. The grass has vigorous seedling habits and is readily established from seed.

Use.—Side-oats grama succeeds well in all locations where other gramas are found except that it needs more moisture than black grama or Rothrock grama. When found in association with them it is confined to low places having extra soil moisture. It succeeds well on raw, disturbed locations if the soil is deep and moisture is adequate, but it is not tolerant of alkali.

Availability of seed.—Seed is now available commercially, and its adaptability to farm production should soon insure an adequate supply from cultivated fields. A local supply of seed may be secured from native stands by hand stripping.

Rothrock Grama

Rothrock grama (*Bouteloua rothrockii* (Vasey)) is a short-lived perennial occurring on mesas, rocky hills, and open ground, in canyons, and among brush in southern Utah and throughout Arizona. It is most prevalent in southern Arizona at elevations between 1,800 and 5,500 feet (fig. 26). It varies from fair to good in palatability but will not withstand heavy use because of its meager root system. It adjusts its stand very quickly to changing moisture conditions from year to year. Because of these characteristics, it should be used in mixture with black grama, side-oats grama, and some of the proven introductions, particularly Lehmann lovegrass.

Seed.—Clean seed averages about 3,000,000 seed units to the pound, but seed material gathered from native stands with a small combine may average from 1,000,000 to as few as 100,000 "live, pure" seed to the pound of bulk planting material, depending upon the amount of trash and empty florets in the material.

Establishment.—Planting in connection with water-spreading or water-concentration structures requires about 15 pounds per acre of average-quality bulk planting material. Results from nursery trial plantings in southern Arizona and New Mexico have been very successful, showing good establishment from seed, rapid growth, production of large clumps of grass, and a good seed crop during a single favorable season.

Black Grama

Black grama (*Bouteloua eriopoda* (Torr.) Torr.), a tufted perennial with numerous fibrous, finely divided roots, is a choice forage grass and the mainstay on many of the drier ranges of the Southwest. However, the fact that it is highly relished by livestock but cannot withstand close yearlong grazing has resulted in a decided decrease in its abundance. It differs from other gramas in that it will spread vegeta-

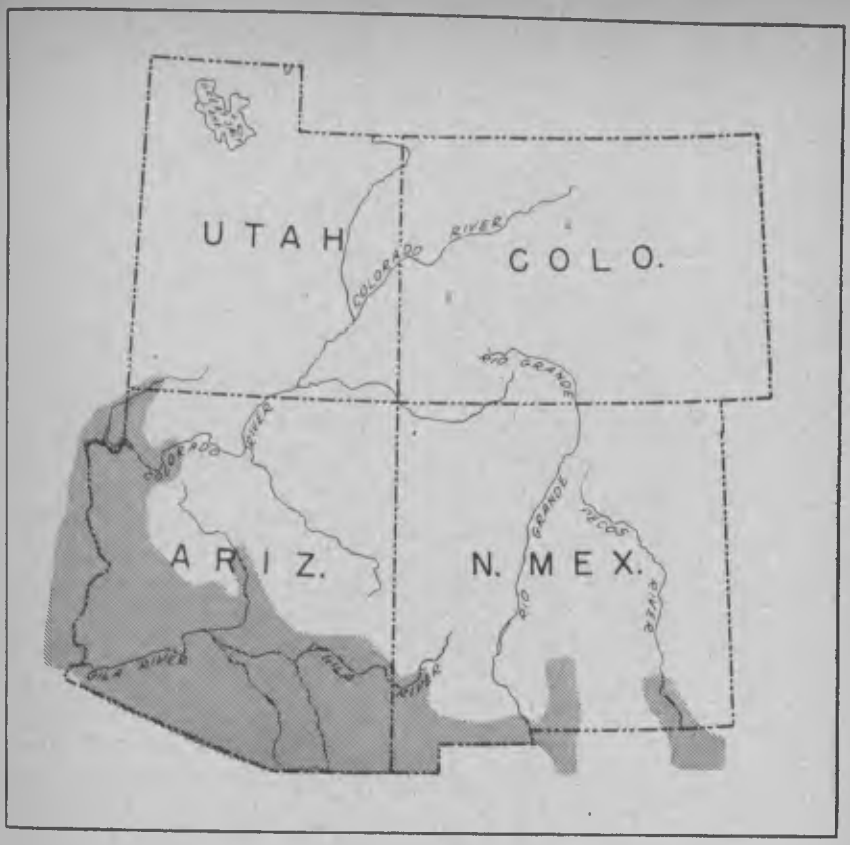

FIGURE 26.—Southwestern areas (shaded) suitable for range reseeding with Rothrock grama.

tively by rooting and establishing new plants at the nodes of prostrate stems (fig. 27). It also reproduces by tillering and by seed.

Seed.—Yield of seed has been rather unsatisfactory, and the seed cannot be separated readily from the straw. Seed is variable in quality and generally has low viability. Although there are about 1,300,000 seeds in a pound, but a pound of average-quality bulk planting material may contain as few as 100,000 "live, pure" seeds.

Establishment.—Only poor to moderate success has attended the use of this species in range reseeding in the area under discussion although excellent results have been obtained from limited plantings in the adjacent southern Great Plains. Because of the generally arid conditions in black grama areas, planting in contour furrows or in connection with other water-spreading, water-concentrating, or water-saving structures is a prerequisite for successful establishment in most instances. About 12 pounds per acre of average bulk planting material is required. Lehmann lovegrass, Rothrock grama, sand dropseed, and mesa dropseed, which produce heavy yields of viable seed that can be harvested readily and cleaned and seeded by farm machinery, have given good results in range reseeding on black grama areas.

FIGURE 27.—Black grama 18 inches high. Note method of spreading by prostrate stems that root at the joints. Open range east of Albuquerque, N. Mex.

DROPSEEDS

The fact that dropseeds commonly are the dominant plants on severely grazed and eroded lands indicates they may be more suitable for revegetation of such sites than some of the more palatable grasses. The dropseeds usually mature an enormous crop of seed in early summer and another in late summer or early fall. As many as 10,000 mature seeds have been obtained from a single seedstalk. Since the seeds are very small, from 2,000,000 to 6,000,000 in a pound, they should not be sown more than one-half inch deep. The seed coats are very hard, and their germination usually is not more than 25 percent unless the seed coat is rendered permeable to water.

Under natural conditions, it has been found that where there are parent plants good stands of seedlings appear in wet years in spite of the hard seed coats. Good emergence follows drought periods when the more desirable grasses have been greatly thinned out. This is probably due to the fact that the hard seed coats prevent early germination, but after several years they finally become water-permeable as a result of wetting, drying, and abrasion by sand particles; thus, a good stand of new seedlings appears in favorable seasons.

Sand Dropseed

Sand dropseed (*Sporobolus cryptandrus* (Torr.) A. Gray) (fig. 28) is found over a wider range of climatic and soil conditions than any other grass in the Southwest. It occurs as a pioneer or invader species in raw, denuded areas and on poor soils everywhere except in the driest desert of the lower Colorado and above the ponderosa pine belt On overgrazed areas, it is one of the first species to respond to lighter use, and its prolific seed habits tend to increase density

rapidly. In somewhat scattered stands, it grows perennially in rather small tufts, usually erect or spreading, but sometimes prostrate. It is very resistant to drought and cold but makes its best growth during hot weather through the summer rainy season.

Depending upon time of use, the plant association, or location in which it occurs, sand dropseed is rated from fair to very good in palatability for all kinds of range livestock. It produces an appreciable amount of palatable forage in the spring.

Seed.—Under range conditions seed is produced in greatest abundance in late summer or early fall; at Tucson, under irrigated nursery conditions, as many as three crops a season have matured, producing over 1,500 pounds of seed per acre in one season. The seed is easily harvested and cleaned. About two-thirds of the seed head

FIGURE 28.—Sand dropseed 2 feet high. Its forage is fairly palatable to all kinds of livestock. Open range, Albuquerque, N. Mex.

is confined in the sheath, so there is very little loss of seed from shattering even though the mature heads stand in the field some time before harvesting. The seed is remarkably long-lived and may lie dormant for many years. Much of the seed that does not germinate the first year will emerge in future years, precluding the necessity of reseeding if the first season's growth is a failure. There are about 5,400,000 seeds in a pound, of which at least 3,500,000 are "live, pure" seeds.

Establishment.—Wherever suited, this species should be used in quantities of not more than one-half pound per acre as a pioneer species in mixture with the more desirable erosion-resistant and forage species. The extreme fineness of the seed requires shallow covering and also makes it difficult to keep the seed from sifting to the bottom of a planter box in mixtures with larger seeds.

Emergence has been generally good where seed was sown less than one-half inch deep. In newly established mixed plantings where livestock have been allowed to graze seeded areas too soon it has withstood abuse better than grama.

FIGURE 29.—Spike dropseed 2 feet high. This species is closely associated with sand dropseed. Open range, Albuquerque, N. Mex.

Availability of seed.—Seed in limited quantities is being collected from native stands for sale; collection on a larger scale may be expected as the demand increases.

Spike Dropseed

Spike dropseed (*Sporobolus contractus* Hitchk.) (fig. 29), although not so widespread, is closely associated with sand dropseed, and to date the results in range plantings of the two species have been almost identical. Good-quality seed averages about 3,000,000 seeds per pound, of which about 2,500,000 are "live pure" seed.

Mesa Dropseed

Mesa dropseed (*Sporobolus flexuosus* (Thurb.) Rydb.) is found on mesas in the southern half of the southwestern region, generally in association with black grama. It is commonly found growing with sand dropseed in such areas but seems to dominate on the deep sandy soils. Seed habits, size, viability, dormancy, and ease of establishment closely resemble those of sand dropseed. Of the approximate 4,000,000 seeds per pound, less than 1,000,000 may germinate readily. Many of the remainder are hard seeds which need after-harvest ripening of 1 or more years before they will germinate. On areas suitable to seeding this grass, ½ to 1 pound of seed per acre should be used in mixtures. It should not be sown alone. Sand dropseed may also be included in the same mixtures except on extremely sandy sites. Native stands can be harvested with a combine.

FIGURE 30.—Giant dropseed 4 feet high. A good grass for sandy locations. West of Albuquerque, N. Mex.

Giant Dropseed

Giant dropseed (*Sporobolus giganteus* Nash), which yields heavy crops of seed, resembles sand dropseed and spike dropseed in seed production, seed habits, and establishment, but it is particularly suited to very sandy locations (fig. 30). It is a robust species, coarser and hence not so palatable as the others mentioned, but it is suitable in all mixtures for use on sandy areas such as dunes, gravelly and sandy washes, and alluvial fans. There are about 2,000,000 seeds in a pound, about one-half of which will germinate readily.

Alkali Sacaton

Alkali sacaton (*Sporobolus airoides* (Torr.) Torr.) is a deep-rooted perennial growing in large, tough bunches in meadows, valleys,

flood plains, and areas having soils of heavy texture and moderate alkalinity (fig. 31). It is found throughout the Southwest except in the driest desert of the lower Colorado.

It is utilized very closely by cattle and horses if grazed during the growing season, especially in the absence of more palatable species, but it becomes coarse, tough, and unpalatable after maturity. This is a valuable species in suitable locations, and in numerous sites it is practically the only species that will succeed. Good yields of hay are cut in many places. Success in reseeding has been variable but some good stands have been secured.

NM-1060

FIGURE 31.—Alkali sacaton. A native stand typical of alkaline flood plains Acoma, N. Mex.

Seed.—Although alkali sacaton is not as heavy a seed producer as some of the other dropseeds, an adequate supply of seed can be obtained from native stands with a combine. Good-quality seed averages about 2,000,000 seeds per pound, of which 1,600,000 are "live, pure" seeds.

Establishment.—About 2 pounds of seed per acre should be sown before summer rains. Moist conditions are necessary for good germination.

Availability of seed.—Seed may be purchased in limited quantities from a few commercial seed houses or may be readily harvested by combines from native stands.

Sacaton

Sacaton (*Sporobolus wrightii* Munro) is a coarse, robust perennial bunchgrass occurring on low alluvial flats, bottom lands, and arroyos subject to flooding (fig. 32). Young growth is very palatable to

ARIZ R-22

FIGURE 32.—Sacaton 6 feet high on a flood plain near Naco, Ariz. This is valuable grass for erosion control.

livestock, but that which matures becomes coarse and tough. The deep, extensive root habit of this grass makes it a valuable erosion-control plant for bottom lands, valleys, alluvial plains, and arroyos, as it will withstand heavy water flows and siltation.

Seed.—A good yield of seed is produced from native stands, but it is difficult to gather more than a part of it as the seed matures unevenly, the early maturing seed shattering while other spikelets still are in bloom. Good-quality seed averages about 2,000,000 seeds per pound, 1,400,000 of which are "live, pure" seeds.

Establishment.—Some very good stands have been secured by very shallow seeding at the rate of 3 pounds of seed per acre on a well-prepared seedbed.

Availability of seed.—Seed can be harvested with a combine from native stands, although some sacaton flats are so rough that seed can be gathered only by hand stripping.

PANICUMS (PANIC GRASSES)

There are many panic grasses, but so far only one native, vine-mesquite, and one introduction, giant panic grass, have been used to any extent under semiarid southwestern range conditions. Discussion of the latter species will be found in the section entitled "Development of Introduced Grasses Adapted to Reseeding Southwestern Ranges," p. 54. Both are summer-growing grasses and should be planted early in the summer rainy season.

Vine-mesquite (*Panicum obtusum* H. B. K.) is one of the most valuable erosion-control plants in the Southwest. Its creeping stems, rooting at the nodes and often growing 8 to 12 feet long in one season, enable it to spread effectively and to form a dense mat that aids in holding the soil in eroding locations. It is particularly useful on critical sites where a protective erosion cover which depends upon seed for establishment cannot be secured. This grass prefers adobe soils but is not confined to them. Although it extends up into the ponderosa pine belt, it is more common on lower areas. It grows under very low rainfall, but generally where additional water is secured from occasional flooding. It produces fair to good feed when green and tender.

Seed.—Seed is rather difficult to obtain. Out of approximately 140,000 seeds in a pound, at best only 35,000 are "live, pure" seeds. Many of the live seeds will not germinate the first year. Fortunately, a very thin stand will soon thicken until it covers the ground.

Establishment.—Since seed is difficult to collect and plants spread readily, 10 pounds of seed per acre will suffice. For critical situations, it has been found that small pieces of sod planted as far as 10 feet apart have spread and covered the ground within 2 years.

Availability of seed.—Seed can be hand-stripped from native stands or harvested with a small combine. The seed does not separate readily from the seed-heads in threshing. A fair amount of seed may be obtained by threshing vine-mesquite hay cut after the seed-heads are mature. The grass may also be seeded by spreading vine-mesquite hay over the area to be planted, and covering it by using a light disk-harrow with the disks set nearly straight.

INDIAN RICEGRASS

Indian ricegrass (*Oryzopsis hymenoides* (Roem and Schult.) Ricker), a densely tufted perennial bunchgrass (fig. 33), is found on a wide

FIGURE 33.—Indian ricegrass. A native stand on very sandy soil in northwestern New Mexico. Annual precipitation less than 7 inches. Shiprock, N. Mex.

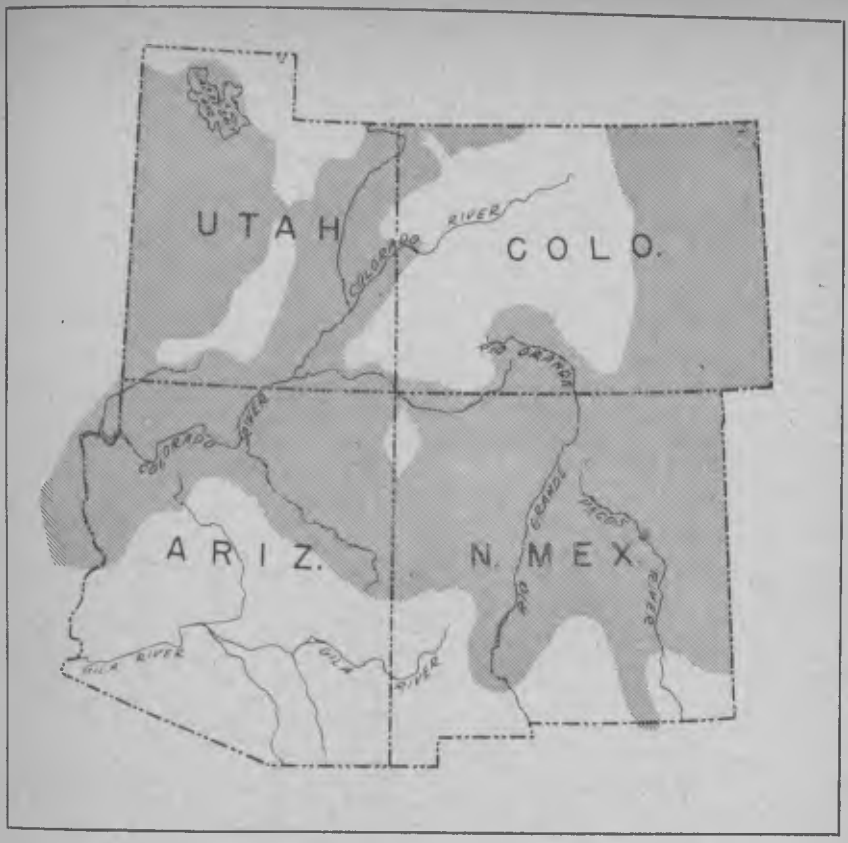

FIGURE 34.—These intermountain and southwestern areas (shaded) have been found suitable for range reseeding with Indian ricegrass.

range of sites (fig. 34). It attains its highest development with blue grama, galleta, needlegrasses, wheatgrasses, dropseeds, and three-awn grasses on the sandier soils. It also may be abundant on heavy adobe soils in association with shadscale and winterfat. It is found on the Escalante Desert in Utah, where the annual precipitation is only 6 inches, and at elevations as high as 10,000 feet on sunny exposed mountain slopes. Its large, nutritious seeds supply good feed for game birds. Stockmen regard it highly as a winter feed. Growth begins very early in the spring and furnishes succulent feed before most grasses start. This is one of the most important species for range reseeding because of its drought resistance, palatability, and ability to grow and spread by natural reseeding where practically no other species can be established.

Seed.—Under favorable rainfall, it produces heavy crops of seed that can be harvested with a combine. Seed-heads should be examined carefully as often they are not filled. The seed averages about 140,000 per pound, of which as few as 60,000 may be "live, pure" seeds. The seed has a very hard coat, which needs to be scarified, treated with acid, or allowed to remain over winter in the soil to make it permeable and allow the seed to germinate.

Establishment.—This species has been considered very difficult to establish, but satisfactory spring germination has been obtained from seedings made the previous year. Seed is too expensive and difficult to obtain to warrant seeding heavily enough for a full stand the first season. As it has been found that stands reseeded naturally and given light grazing use will increase rapidly, it is estimated that seeding at a rate of 10 to 15 pounds per acre will give a very satisfactory stand within a 5-year period.

Availability of seed.—Seed can be harvested by a combine from native stands. Nursery plantings indicate that seed can be produced economically from cultivated plantings.

HILARIA

This group of grasses is common to much of the semidesert and desert areas of the Southwest. Big galleta (*Hilaria rigida*) probably is the most drought-resistant perennial grass in the United States. As a group, these grasses prefer the finer textured adobe soils but are not confined to them. They are found in association with grama, dropseed, and three-awn grasses. With the exception of galleta (*Hilaria jamesii*), they are found with mesquite and creosote shrubs. Having vigorous runners and rootstocks or extensive, strong, fibrous root systems, they bind the soil very effectively. On southwestern ranges they are particularly important because of their abundance, quick growth, response to limited moisture, drought resistance, and ability to stand relatively heavy use.

Use of these grasses in range reseeding has been restricted because of the difficulty of securing seed. Some very extensive native stands are to be found, but the seed-heads are often poorly filled, and the seeds mature unevenly and drop out of the husks soon after ripening. Many unfamiliar with this habit have harvested what was thought to be seed, but found that only empty husks had been secured. Ranchers probably can secure enough seed from nearby stands since they can watch them closely and collect seed on short notice. Seed of all species should be planted one-half inch deep.

Galleta

Galleta (*Hilaria jamesii* (Torr.) Benth.), a strong-rooted, erect perennial with tough woody rootstocks, is abundant over extensive areas in the upper plains and in the lower limits of the ponderosa pine belt of Arizona and New Mexico west of the Pecos River at elevations of 5,000 to 7,000 feet (fig. 35) and occurs in abundance at lower elevations in eastern New Mexico. It occurs chiefly in scattered stands in Utah and Colorado on mesas, plains, and deserts, usually in association with blue grama and sagebrush. It attains its major development on the heavier textured soils that are slightly alkaline or limy. Such soils frequently are found in partially denuded and eroded areas. The species is associated with shale outcrops and shale-derived soils. It probably is the grass best adapted to sites where salinity is not too great and where moisture is too limited for alkali sacaton. Palatability is good to very good, depending upon the season.

Seed.—There are about 180,000 seeds in a pound, of which 72,000 are "live, pure" seeds.

FIGURE 35.—Galleta 18 inches high. It is a strong-rooted perennial, common in New Mexico and Arizona and in scattered stands elsewhere. Open-range specimen near Albuquerque, N. Mex.

Establishment.—In most instances this species should be used in mixture with some of the following, depending upon the site: Sand dropseed, spike dropseed, western wheatgrass, side-oats grama, blue grama, alkali sacaton, and Indian ricegrass.

Availability of seed.—Seed can be harvested with a combine from native stands. The seed-heads should be examined carefully to make sure they contain a good percentage of seed. The seeds drop out of the hulls very soon after ripening. Harvest periods are very short, but both a June crop and an early September crop may be produced on the range if moisture conditions are favorable.

Tobosa

Tobosa (*Hilaria mutica* (Buckl.) Benth.) resembles galleta in general appearance. Its range in the Southwest is south of the galleta belt, in approximately the same territory where mesquite bush is found. It prefers fine-textured adobe soils, the best stands being found in adobe flats and swales subject to flooding. Livestock eat tobosa readily when it is green, but if other feed is available they will avoid tobosa after growth ceases and it becomes tough and dry. Its tough, woody rootstocks and strong roots enable it to withstand trampling and renders the sites on which the grass is found very resistant to erosion.

Seed.—There are about 265,000 seeds in a pound, although bulk planting material may have as few as 26,000 "live, pure" seeds to the pound.

Establishment.—It is advisable that tobosa seedings be made in connection with water spreading or detaining structures where dry conditions prevail. Planting should be done just before or early in the summer rainy season.

Availability of seed.—This grass is similar to galleta in respect to availability and harvesting of seed.

Curly Mesquite

Curly mesquite (*Hilaria belangeri* (Steud.) Nash) differs from the other Hilaria species because of its small size and slender wiry runners (fig. 36). It also is more valuable as a range grass because it is relished by livestock at all seasons of the year. It occupies local areas of dry clay soil and rocky soils in southwestern New Mexico and southern Arizona at elevations between 3,500 to 5,500 feet. It forms a compact sod very resistant to erosion, stands considerable trampling, and spreads readily by means of its numerous runners.

Seed.—Curly mesquite, like galleta and tobosa, will produce two crops of seed a year, but seed is difficult to secure as it drops out of the husk upon ripening. Seed averages 275,000 to the pound, of which generally about half are "live, pure" seeds.

Establishment.—Curly mesquite is similar to tobosa with respect to conditions of establishment.

Availability of seed.—Seed in adequate amounts is very difficult to obtain from native stands. Good seed production has been obtained from irrigated plantings of curly mesquite at the Soil Conservation Service nursery at Tucson, Ariz. (fig. 37). Under irrigation the plants spread rapidly and form a dense sod. Farm plantings for seed production can be pastured after seed-collecting operations are over for the season. An irrigated curly mesquite planting is very similar to a

NM—9040

FIGURE 36.—Nursery-grown curly mesquite, showing how plants spread vegetatively. Note connecting runners between mother plant and succeeding offshoots. Tucson Soil Conservation Service nursery.

Bermuda grass pasture but the forage is more palatable after frost than Bermuda. Cleaning up the excess cured growth through grazing in the fall and early winter will benefit a planting of curly mesquite. Care should be taken, however, not to allow the planting to be trampled excessively or grazed too closely since the plants are established on the surface and do not have underground stems, as does Bermuda grass.

ARIZ—4107

FIGURE 37.—Irrigated seed-increase planting of curly mesquite at the Soil Conservation Service nursery, Tucson, Ariz., established by small transplants set several feet apart in 3-foot rows. Note how plants have spread in two seasons, forming a dense sod except for a few bare spots where the transplants failed to catch.

BEARDGRASSES

The beardgrasses are most abundant in the Plains States, but some of the more drought-resistant species are abundant in portions of the Southwest. All are summer-growing, deep-rooted perennial grasses usually with a bunch habit of growth. The solid or pithy stems are fairly leafy. While green and growing, the forage is relished by livestock and produces a good volume of palatable hay if cut at the proper time. It becomes coarse and tough upon maturity. The feathery character of the seed has been a decided handicap in the use of the beardgrasses in range reseeding in the past since the seed could not be handled by available harvesting and seeding machinery. Recently developed methods of seed processing remove the feathery seed appendages. Seed of at least one of the beardgrasses, little bluestem (*Andropogon scoparius*), can be purchased through commercial seed houses.

Little Bluestem

Little bluestem (*Andropogon scoparius* Michx.) is a deep-rooted perennial bunchgrass which occurs sparingly on the coarser textured soils and rocky slopes of the woodland and ponderosa pine belts (fig. 38). It is the predominating species on the dry, sandy, and gravelly soils in the northern Pecos Valley of New Mexico. Palatability is

fair to good in early spring, but the plants become tough and wiry after maturity. It makes good hay if cut early in July before the plants become "stemmy."

Seed.—There are about 300,000 seeds in a pound. Although only 60,000 of these are "live, pure" seeds, this is largely compensated for in range plantings by the vigor of the young seedlings. During the first year new plants may reach a height of 6 to 8 inches, tiller profusely, and produce seed.

Establishment.—Fair to good results have been secured in observational trial plantings. Ranchers who have no means of threshing or processing seed may obtain a good stand by collecting seed-heads and broadcasting the chaffy seed material evenly over the prepared area, covering it by running a cultipacker or disk over the ground. From 15 to 20 pounds of seed per acre should be planted one-half inch deep in a well-prepared, firm seedbed. It is now possible to process seed by running it through a hammer mill so that it can be handled with farm planters.

Texas Beardgrass

Texas beardgrass (*Andropogon cirratus* Hack.) may be confused with the little bluestem (prairie beardgrass) of the southern part of New Mexico and Arizona. It differs from little bluestem in being more palatable and more important in erosion control. Seed must be collected from local native stands.

NM–9053

FIGURE 38.—Little bluestem, a deep-rooted perennial bunchgrass. It is the predominating species on the dry, sandy, and gravelly soils of the northern Pecos Valley.

Silver Beardgrass

Silver beardgrass (*Andropogon saccharoides* Swartz) is a perennial bunchgrass found in scattered stands in well-drained soils along gullies swales, and in eindery, rocky soils of the foothills in southern New Mexico, Arizona, and California.

Its drought resistanee and fair to good forage value makes this a valuable range and erosion-control grass in an area where it is diffieult to secure a stand of grass from seed.

The seed is very fluffy and hard to handle but can be gathered by hand from local stands. It germinates readily, and the seedlings are very vigorous. There are about 384,000 seeds in a pound, 150,000 of which are "live, pure" seeds.

Sand Bluestem

Sand bluestem (*Andropogon hallii*), also known as turkey foot, is a deep-rooted bunchgrass which grows vigorously on very sandy areas with as little as 10 inches annual precipitation. It has short, thick rootstocks which, with heavy seed production, enable the species to maintain and increase its stand. The forage is not readily eaten by livestock except when growth first starts in the spring. It is a valuable grass for stabilization of sand dunes. Establishment from seeding has been very satisfactory. Seed has to be collected from local stands.

PLAINS BRISTLEGRASS

Plains bristlegrass (*Setaria macrostachya* H. B. K.) is a tufted perennial grass, 1 to 3 feet tall, producing rather light green, tender forage. It is particularly valuable in establishing a quick ground cover on raw, denuded areas (fig. 39). It is found in scattered stands over New Mexico and Arizona and also occurs at the lower elevations in Colorado. This species has produced over 500 pounds of seed per acre under irrigation at the Soil Conservation Service nursery at Tucson, Ariz. The seed is difficult to obtain from the native stands, which are thin and scattered. Observations made at the Soil Conservation

NM—11721

FIGURE 39.—Initial seed-increase rows of a productive strain of plains bristlegrass growing at the Soil Conservation Service nursery near Albuquerque, N. Mex.

Service nursery at Tucson indicate that newly harvested seed does not germinate readily, but following a period of storage it germinates quickly. Survival of the seedlings has been good. Its best use is in mixture with other grasses to obtain a quick ground cover on denuded areas while the slower, more permanent grasses are becoming established.

BUSH MUHLY

Bush muhly (*Muhlenbergia porteri* Scribn.) is a very drought-resistant grass found on the dry mesas and foothills under the protection of mesquite, catclaw, creosotebush, cactus, and other associated species. It appears to grow well in the open but its high palatability has caused its disappearance from all open areas except protected ranges. The stems, which remain green and highly palatable throughout the year, are freely branching, leafy, and somewhat sprawling, attaining lengths of from 2 to 4 feet (fig. 40). It has coarse, fibrous, somewhat woody roots. The weak and sprawling habit of the stems allow them to be covered by soil, and the prominent nodes layer root readily. In this manner, clumps extend their size greatly.

NM -9041

FIGURE 40.—Bush muhly, a drought-resistant grass found on the dry mesas and foothills. Note the long slender stems, which remain green and highly palatable to livestock the year round.

Seed.—A high percentage of the seed germinates in 30 to 48 hours' time. It has been impossible to secure clean seed in any quantities as it is almost impossible to thresh and clean seed with ordinary equipment. The weak stems break up into very small pieces and cannot be separated readily from the seeds. The seeds are long, slender, and easily broken. This prevents vigorous handling in an attempt to obtain clean seed.

Establishment.—The trashiness of the seed prevents its handling by drills; consequently it must be broadcast by hand and covered lightly.

Availability of seed.—Seed must be harvested by hand from native stands. Methods of field production are being studied, and it is hoped that seed of this valuable range species can be grown commercially.

COTTONTOP

Cottontop (*Trichachne californica* (Benth.) (Chase) is a coarse, leafy, tufted bunchgrass with a tough knotty base and slender, erect stems 1 to 3 feet high. It occurs in rather scattered stands throughout the more arid portions of the Southwest. New growth at the base of the clumps remains green all winter and resumes growth early in the spring. Another and stronger new growth appears after the summer rains. Livestock eat the forage readily while it is green but not after it becomes tough and woody.

Good results have been obtained from range seedings. Seed can be gathered by hand from scattered local stands. Four crops of seed have been harvested from irrigated nursery plantings at Tucson, Ariz., giving a total seasonal yield of 2,000 pounds of fluffy seed. This seed is rather difficult to harvest and separate from stems and leaves but the bulk can be processed with a hammer mill and clean caryopses obtained.

MONT—10017

FIGURE 41.—Plant of giant wild-rye growing under natural conditions.

GIANT WILD-RYE

Giant wild-rye (*Elymus condensatus* Presl.) is a coarse, robust, fall- or spring-growing grass associated with the wheatgrasses and big sage brush on valley bottoms where there is a plentiful moisture supply (fig. 41). It has a deep, extensive root system and spreads from seed and short, thick root-

stocks. It is palatable when young, producing enormous forage yields, but soon becomes coarse and tough. This grass is valuable for range reseeding on flood plains. Seed can be harvested by combine from native stands. It should be drilled 1 inch deep in the late fall.

BIG SANDREED

Big sandreed (*Calamovilfa gigantea* (Nutt.) Scribn. and Merr.), also known as giant sandreed, is a large, robust grass, 4 to 6 feet tall, with strong, creeping, underground rootstocks, occurring in sand dunes and washes in the Southwest. It is practically worthless for forage but is a highly desirable grass for controlling sand dunes in droughty areas.

Seed.—Seed must be harvested by hand from native stands although short row plantings on the Soil Conservation Service nursery near Albuquerque produce good crops of well-filled seed-heads. Collection of seed by the use of harvesting machinery would probably be difficult since the plants grow very tall and rank.

PRAIRIE SANDREED

Prairie sandreed (*Calamovilfa longifolia* (Hook.) Scribn. and Morr.), also known as prairie sandgrass, is a coarse, tough, drought-resistant grass having strong rootstocks and rigid, leafy stems 2 to 6 feet tall. It occurs on sand ridges and dunes in the northern portion of Pecos Valley in New Mexico. Its numerous rootstocks and coarse, fibrous, deep roots are very effective in binding drifting sand. The foliage is not relished by livestock in the growing season, but it cures well and is an important source of feed for cattle in many sandhill and dune areas. It also makes fair hay.

Seed.—A fair yield of seed may be harvested by combine from native stands.

Establishment.—It is fairly easy to establish a stand from seed. Although this grass is found growing native in only the eastern portion of the Southwestern Region, trial plantings have been more successful than those of giant sandreed, even where the latter was found to be growing naturally. Seed should be sown 1 inch deep.

REED CANARY GRASS

In the northern part of the region, reed canary grass (*Phalaris arundinacea* L.) furnishes heavy crops of forage and hay on fertile, moist, or swampy soils. A drought-resistant strain (Highlands) has given excellent results in range plantings in Utah with as little as 14 inches of annual precipitation. A complete discussion of this grass, its use, range, adaptations, and establishment may be found in United States Department of Agricultural Farmers' Bulletin 1602, entitled "Reed Canary Grass." Seed may be purchased on the commercial market.

SMOOTH BROME

The good qualities of smooth brome (*Bromus inermis* Leyss.) are too well known to warrant a lengthy discussion here. However, little use can be made of this grass in southwestern range plantings except in the higher elevations where the annual precipitation is over 16

inches. It will not succeed on land too dry for alfalfa. Seed can be purchased at a reasonable price.

DEVELOPMENT OF INTRODUCED GRASSES ADAPTED TO RESEEDING SOUTHWESTERN RANGES

Several exotic grasses grown under observation in the Soil Conservation Service nurseries are proving valuable for range reseeding in the Southwest. Three of these foreign species, weeping lovegrass, Lehmann lovegrass, and giant panic grass, have shown through their performance in trial plantings both in the nurseries and on the range that they have a definite place in the range reseeding program, especially in the central and southern portions of the Southwestern Region.

These grasses were obtained and tested for erosion control and revegetation purposes by F. J. Crider, in charge, Soil Conservation Service nursery, Tucson, Ariz., in 1934. Seeds of the lovegrasses were acquired from M. Wilman, Kimberley, South Africa, and those of giant panic grass from the Department of Agriculture, Sydney, Australia, through the Division of Plant Exploration and Introduction of the Bureau of Plant Industry. The initial tests at the Tucson nursery having shown that these grasses possessed desirable qualities for range reseeding, extensive trial plantings were undertaken on problem areas throughout the Southwest Region.

WEEPING LOVEGRASS

Weeping lovegrass (*Eragrostis curvula* (Schrad.) Nees) is a robust, tufted perennial bunchgrass with numerous slender, curving basal leaves 10 to 20 inches long and seedstalks 2 to 5 feet (fig. 14). It has a deep, well-branched root system. This grass produces a good volume of palatable forage although, when associated with other grasses, it may not be eaten as readily as some other range grasses during the summer rainy season when they are all in active growth. As the other grasses mature, however, and become dry, weeping lovegrass continues to be palatable since the basal leaves in the heavy clumps remain partially green. It also produces good spring forage.

The northern limit of the range of this grass, indicated by numerous field plantings, probably coincides with that of the mesquite bush belt (fig. 42). Although not adapted to general range planting in the region under discussion, because of the volume of forage produced when growing in favorable sites it may be considered a good "special place" grass. Trial plantings have shown that this grass, when once well established, does well in contour furrows, on areas which receive occasional flooding, in depressions and spots on the range where debris has accumulated and moisture is retained, and at higher elevations where the annual rainfall is more than 12 inches and winter temperatures do not fall too low.

Seed.—There are about 1,500,000 seeds to the pound, of which 1,125,000 are "live, pure" seeds. The seed is large enough to be picked up by quail and other small birds. The grass is well adapted to farm production of seed, yields of 500 pounds of clean seed per acre having been harvested from irrigated plantings on the Soil Conservation Service nursery at Tucson, Ariz. (fig. 14). Under irrigation in the hot valleys of the Southwest one heavy seed crop is matured in early summer. Vigorous growth continues until late fall. Al-

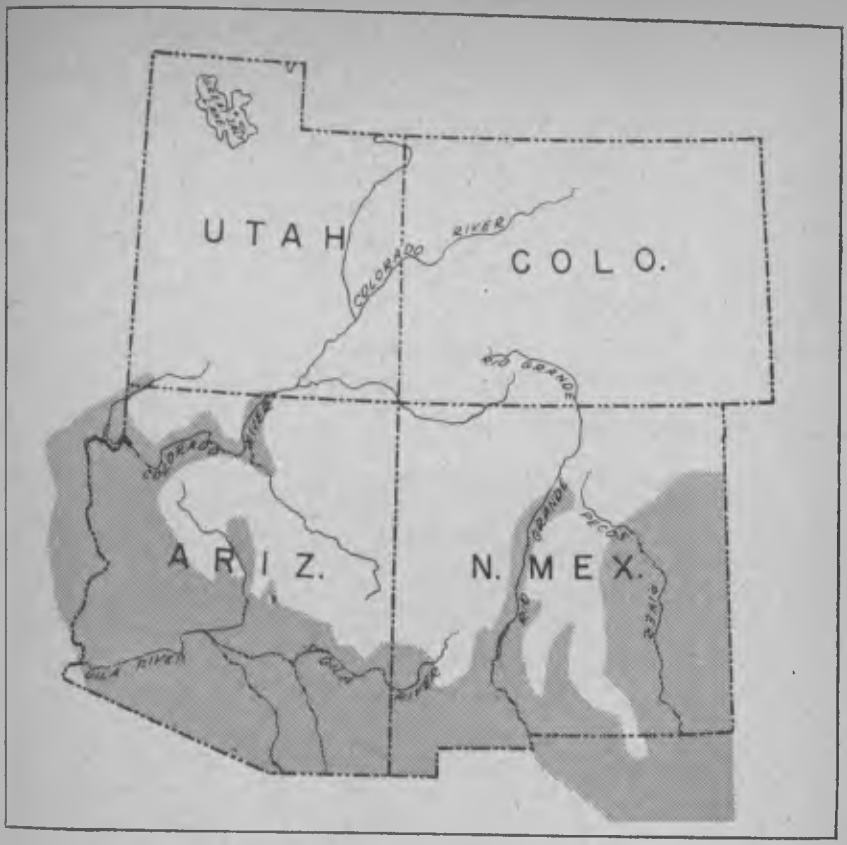

FIGURE 42.—These southwestern areas (shaded) have been found suitable for range reseeding with weeping lovegrass and giant panic grass.

though additional seeds are produced, this second growth is more suitable for hay, as the seed-heads produced during very hot weather are poorly filled and have usually been found not to be worth harvesting for the seed they contain. In range plantings, if moisture conditions are favorable, a light crop of seed is matured in the spring and a heavier crop in the fall following the summer rains.

Seed produced under cultivation is harvested and threshed with a small combine and comes from the thresher as clean, naked seed. Since there is very little chaff and other foreign matter, it can be planted readily with farm planting machinery.

Establishment.—Seed germinates quickly, and the seedlings are vigorous. Although not so drought-resistant as Lehmann lovegrass during the seedling stage, if it is planted on favorable sites and in connection with moisture-detaining devices a stand can be established readily. Weeping lovegrass is a summer-grower and should be planted early in the summer rainy season, about one-half inch deep and generally in mixture with other grasses. When it is planted alone, a rate of 2 or 3 pounds of seed to the acre is adequate.

Availability of seed.—A limited amount of seed has been released to the Arizona and the New Mexico State Agricultural Experiment

Stations to be placed with competent cooperators for increase, and farm-produced seed should soon be available.

LEHMANN LOVEGRASS

Lehmann lovegrass (*Eragrostis lehmanniana* Nees) is a perennial grass growing 1 to 2 feet high and producing a good tuft of tender basal leaves (fig. 43). The stems are rather fine and weak. Where it is adapted (fig. 44), better success in range reseeding has been obtained with the use of this species than with any other grass. It is easily established, and the stand increases and spreads by natural reseeding and through the establishment of new plants by rooting at the nodes of the prostrate stems. It has proved to be very drought-resistant and produces a good amount of palatable forage. This grass is not as winter-hardy as weeping lovegrass but is more drought-resistant, especially during the seedling stage. The results of numerous field plantings indicate that the use of Lehmann lovegrass should

FIGURE 43.—Nursery-grown plant of Lehmann lovegrass 18 inches high. Note prostrate stems that root at nodes.

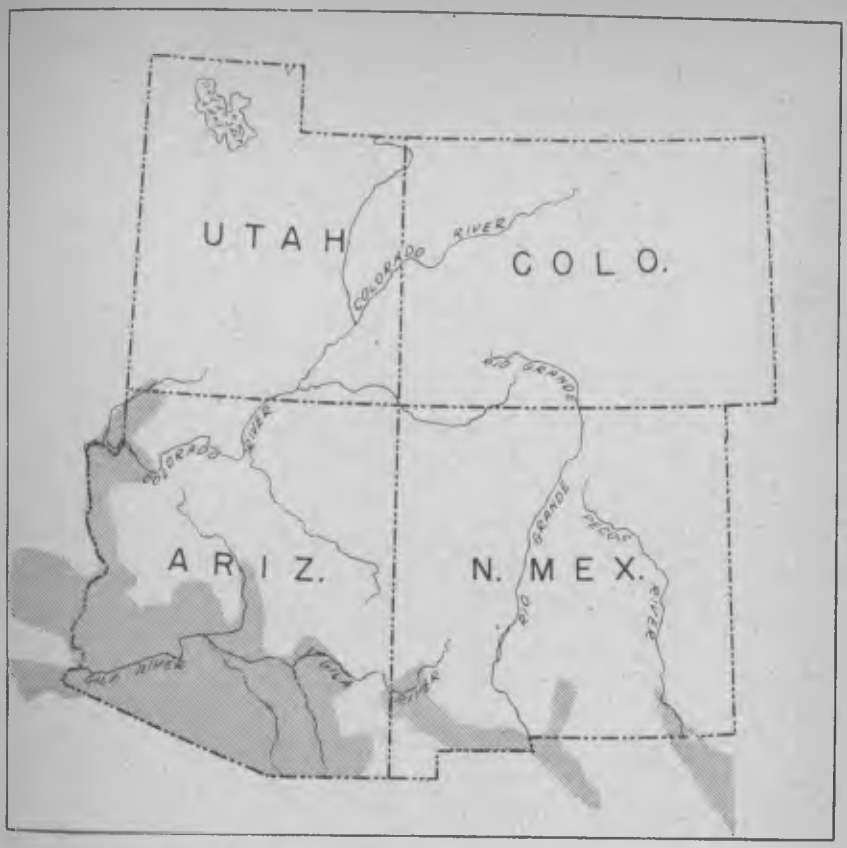

FIGURE 44.—Through trial plantings these southwestern areas (shaded) have been found suitable for range reseeding with Lehmann lovegrass.

generally be restricted to about the same range as native creosotebush. In range plantings new forage and a light crop of seed are produced in the spring and a heavier growth and seed crop during the summer rainy season.

Seed.—This grass is well adapted to farm-seed production. Over 500 pounds per acre of clean seed has been harvested with a small combine in one season from plantings on the Soil Conservation Service nursery at Tucson, Ariz. The seed is harvested from two crops, one maturing in early summer and the other rather late in the fall. In between these seed harvests and during the hot summer months a good growth is produced which can be cut for hay as the seed heads contain very little seed. There is an average of over 7,000,000 seeds in a pound, of which some 5,000,000 are "live, pure" seeds. Newly harvested seed may show a low percentage of germination, but an after-ripening process takes place in stored seed, and germination improves until it may reach 90 percent. Seed harvested one summer germinates satisfactorily if planted during the following summer.

Establishment.—Because of the small size of the seed, this summer-growing grass should be planted at shallow depths, not over one-half inch. It should be planted early in the summer rainy season in a

mixture with other adapted grasses. It has been established on soils of nearly all textures, but when it is planted under extremely dry conditions additional moisture should be supplied by means of contour furrows, spreaders, or other similar devices. One pound of seed per acre has proved an adequate amount in many range seedings where uniform distribution and proper seeding methods have been followed.

Availability of seed.—Similar to weeping lovegrass.

GIANT PANIC GRASS

Giant panic grass (*Panicum antidotale* Retz.) (fig. 45) is a robust, deep-rooted perennial grass from Australia, where it is an important range-plant species and very cosmopolitan in its adaptation to different soils. Under favorable conditions the canelike, branching stems form a large bushy plant 6 to 8 feet in height that produces an abundance of succulent leaves. Although not adapted to general range planting, giant panic grass, like weeping lovegrass, is a valuable "special place" grass and is suited for planting in washes and arroyos, above dikes, on flood plains and desilting areas, and around stock tanks. Because of its deep root system, stout canelike stems, and ability to root at the nodes, giant panic grass is a valuable plant for use in desilting areas and for protective plantings along stream banks where it is desirable to build up the banks with silt deposited from the floodwaters. As silt is deposited around the plants, new roots form at the nodes just below the new soil surface, and the plant establishes a new base while the old stalks and roots deeper in the soil still continue to function. Giant panic grass will grow on sites where Johnson grass will grow, is as drought-resistant, and produces a comparable volume of forage. In fact it might be considered as a superior substitute for Johnson grass in plantings where this grass will succeed. Like Johnson grass, it thrives in the Southwest where there is sufficient moisture, and temperatures do not fall too low and in favored sites in drier areas where there is a concentration of moisture. It is not so aggressive as Johnson grass, but on the other hand it is not such a weed menace, and up to the present time there has been no indication that giant panic grass develops the poisonous qualities which characterize Johnson grass under certain stress conditions.

Seed.—Under irrigation at the Tucson nursery, giant panic grass produces good crops of viable seed. The seed ripens continuously and shatters rather readily from early summer until late fall. Heavy yields of nearly a ton to the acre have been collected by cutting the mature heads by hand every week throughout the growing season. Where the seed is harvested by machinery, yields are reduced to an average of 500 pounds per acre owing to shattering of the ripe seed and the quantity of immature seed. The seed makes excellent food for game birds, and the plants provide good cover. There are 700,000 seeds in a pound, of which 455,000 are "live, pure" seeds.

Establishment.—The seed should be sown early in the summer rainy season and should be planted about one-half inch deep in a firm seedbed. When giant panic grass is planted alone, 6 to 8 pounds to the acre should produce an adequate stand.

Availability of seed.—Seed released through the Arizona State Agricultural Experiment Station has been planted for increase by a few farmers in the southern part of the State.

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FIGURE 45.—Giant panic grass growing at the Soil Conservation Service nursery near Albuquerque, N. Mex. Plants were established by irrigation in 1936, and the growth shown in this photograph was produced without irrigation in 1937.

FURTHER STUDIES

The grasses listed in this bulletin are not the only ones of value in range reseeding in the Southwest. They are, however, those which have proved most practical for planting and most likely to survive. Many others are under test, and in the future some of these may be important in the range revegetation work in this region. Similarly, many legumes are under observation, but so far the development of adapted species and strains of legumes and their use in range plantings have not advanced far enough to warrant discussion here.

ASSISTANCE TO RANCHERS

The United States Department of Agriculture, through its various programs, is extending direct financial aid and technical assistance to ranchers to help apply the principles of range conservation suggested by these findings. Ranchers and farmers interested in range revegetation may obtain information on how to make use of such assistance from representatives of the Soil Conservation Service and Agricultural Adjustment Agency stationed in their vicinity.

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